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Environmental Impact Assessment of Motorcycle Exhaust Emission Regulations

Energy and Environmental Analysis, Inc, Arlington, Va

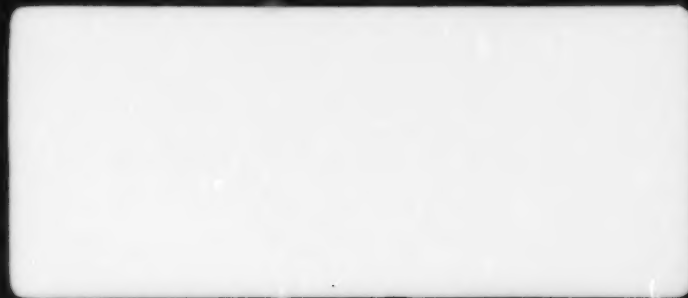
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**OFFICE OF
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**ENVIRONMENTAL IMPACT
ASSESSMENT
OF
MOTORCYCLE EXHAUST
EMISSION REGULATIONS**

Prepared for:

**Environmental Protection Agency
Office of Mobile Source Air Pollution Control
Office of Air and Waste Management**

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CHAPTER I

SUMMARY

Between now and 1990, motorcycle emissions, if left uncontrolled, are expected to increase by over 100 percent. Over the same time period, emissions of other sources will be significantly curtailed as attainment of acceptable air quality is pursued, and the importance of motorcycle emissions in finally achieving the air quality standards will be increasingly important. A large number of the regions in the United States presently exceeding the air quality standards for oxidants and carbon monoxide (CO) will continue to have difficulties in achieving or maintaining these standards in the 1980's. Uncontrolled emissions from motorcycles would add to this burden.

Motorcycles are one of many small but significant sources of emissions. Present uncontrolled motorcycles emit about two times as much CO and about six times as much hydrocarbons (HC) as new 1976 automobiles. When statutory standards for automobiles are met, uncontrolled CO emissions will be ten times as high and HC over twenty times as high for the motorcycle. Equitable distribution of the burden of control for emissions from personal transportation would indicate that control of motorcycle emissions is required. Based on these facts, EPA is preparing to propose emission standards for new motorcycles sold in the United States.

A. The Proposed Standards

Section 202(a) of the Clean Air Act gives the Administrator of EPA the authority to set emission standards for new

motor vehicles. Under this authority, EPA is intending to propose both interim and long-term emission standards for motorcycles designed for street use. The 1978 interim standard for hydrocarbon exhaust emissions is dependent on engine displacement, requiring control to 5 grams per kilometer (g/km) for motorcycles between 50 and 170 cubic centimeters (cc) displacement. The standard increases proportionately with displacement from 5 g/km at 170 cc to 14 g/km at 750 cc. The 14 g/km standard holds for all motorcycles over 750 cc. Also, for 1978, carbon monoxide emissions are limited to 17 g/km and nitrogen oxide emission (NO_x) are limited to 1.2 g/km. Crankcase hydrocarbon emissions are prohibited in 1978.

These standards, if met throughout the life of the motorcycle, will decrease average motorcycle emissions of hydrocarbons by 30 percent and carbon monoxide emissions by 22 percent. Nitrogen oxide emissions which are inherently quite low will increase somewhat as HC and CO are controlled.

The long-term standards which are to be met by the 1980 production year will be at the same level as those for light duty vehicles. The control standards of 0.25 g/km HC and 2.1 g/km CO represent reductions of 95 and 90 percent respectively.

B. Motorcycle Use and Growth Projections

The present population of registered motorcycles is approximately 4.9 million. Registrations have grown rapidly over the last ten years at a rate of over 17 percent per year. Although this rate of growth is unlikely to continue through 1990, the population is projected to exceed 11 million by that time.

As one would expect from the nature of motorcycles and motorcycle use, registrations are not evenly distributed throughout the United States. Density is highest in the Pacific and Western regions of the U.S. - in many areas exceeding 2 motorcycles per hundred persons.

Emissions from uncontrolled motorcycles vary with engine displacement and type (2-stroke or 4-stroke). In general, 2-stroke motorcycles emit about six times as much hydrocarbon as 4-stroke motorcycles. Carbon monoxide emissions are more a function of engine displacement than engine type. The present mix of motorcycles on the road is about 40 percent 2-stroke and 60 percent 4-stroke.

Based on a recent survey of motorcycle use and ownership, it appears that, on the average, small motorcycles (less than 170 cc) have an average usage life of 5.5 years and accumulate 12 thousand kilometers. Larger motorcycles (greater than 170 cc) have an average life of over 7 years and accumulate an average of 30 thousand kilometers of use. Approximately 15 percent of the existing registered population of motorcycles is scrapped each year.

Growth, scrappage, and usage rates all play a part in determining both the level of emissions and the rate at which new controlled motorcycles replace older uncontrolled motorcycles, and thereby reduce total motorcycle related emissions.

C. Environmental Impact of Motorcycle Emissions

In areas where motorcycle registrations are high and air quality for oxidants and carbon monoxide is poor, motorcycles can be an important factor in the attainment or non-attainment of acceptable air quality. In the late 1970's, in areas such as Los Angeles and Phoenix, motorcycles will be

responsible for about 5 percent of the total emissions of carbon monoxide and hydrocarbons.

Nationwide, the contribution of motorcycles to total emissions is less. Uncontrolled motorcycle emissions are estimated to be 0.7% of HC and 1.3% of CO emissions nationwide in 1980. Without control these levels rise to about 1.5% and 3.5% respectively in 1990. The proposed standards effectively reduce motorcycle emissions to below 0.1% and 0.5% for HC and CO respectively in 1990.

Any and all regions of the United States which are not meeting air quality standards for carbon monoxide and photochemical oxidants will benefit in some way from these control standards, as they will serve as one of many strategies to help reduce overall emissions of HC and CO and thereby improve air quality. About one-third of the U.S. population (68 million) lives in areas which are projected to have problems meeting these air quality standards in 1985. Areas which have both large motorcycle populations and long-term air quality problems include most of California, Salt Lake City, Phoenix-Tucson, and Denver. Over 20 million people now live in these areas.

Secondary environmental benefits of the proposed regulations will be lower particulate and smoke emissions from motorcycles, lower photochemical reactivity of the hydrocarbons which are emitted, slight potential reductions in street surface run-off pollution, and improved motorcycle fuel economy at least in production years 1978 and 1979. Potential disadvantages will be slight increases in nitrogen oxides, possible sulfate emissions from post-1979 motorcycles, and the unknown compatibility of emission controls with future regulations of motorcycle noise.

D. Economic Impact of Motorcycle Standards

Four Japanese companies dominate the motorcycle industry. Honda accounts for roughly 43 percent of total sales, with Suzuki, Kawasaki and Yamaha accounting for another 44 percent. The only major domestic manufacturer is Harley-Davidson, accounting for around 6 percent of the total number of motorcycles sold each year. Most of the employment in the U.S. associated with the motorcycle industry is related to sales and distribution of motorcycles and secondary products.

Estimates of the cost of achieving both the interim 1978 standards and the long-term 1980 standards are highly uncertain. Since no standards exist, the manufacturers have only performed a limited amount of research and development. The proposed interim standards were deliberately set at levels that were considered achievable with a minimum of disruption. The 1980 standards are expected to be more difficult to achieve, but attainable. Cost estimates for the 1978 standards range from \$20 to \$40 per motorcycle. Estimates for 1980 are subject to considerably more uncertainty. A range of \$50 to \$130 per motorcycle was used in this analysis for illustrative purposes. Because of uncertainties about both control system costs and the relative ability of various manufacturers to achieve the long-term standards at a particular cost, overall impact on the industry cannot be specifically identified at this time. As an example, however, if one assumes the control system in 1980 causes a 10 percent average increase in the first cost of a motorcycle, and assumes a price elasticity of demand of 0.7, one would predict a 7 percent drop in sales.

If the control of emissions costs the same for each motorcycle, the cost-effectiveness will be greatest for the dirtier, large 2-stroke motorcycles. Conversely, control of small 4-stroke motorcycles, at the same cost, would be less cost-effective.

Until additional research is performed on the various control options (engine redesign, exhaust after treatment, etc.) available to motorcycle manufacturers, little of a definitive nature can be said about the eventual economic impact of the long-term standards.

Chapter II

INTRODUCTION

A. Description of Proposed Action

Section 202 (a) of the Clean Air Act gives the Administrator of EPA the authority to set emissions standards for new motor vehicles and motor vehicle engines which in his judgment cause or contribute to air pollution which endangers the public health or welfare. This section further prescribes that such regulation shall take effect after a period necessary to permit the development and application of the requisite technology.

Section 214 of the Act defines "motor vehicle" as "any self-propelled vehicle designed for transporting persons or property on a street or highway." This definition clearly includes motorcycles licensed for operation on highways. However, Section 85.001 of 40 CFR Part 85 presently excepts motorcycles from the regulations which apply to light duty vehicles.

The EPA is intending to propose both interim and long term emission standards for new motorcycles. To assure achievement of the desired standards, prototype motorcycles designed for street use will be tested over a simulated driving cycle on a stationary testing apparatus to check the levels of emissions prior to certification for sale in the United States. The interim standards being proposed for the 1978 production year are believed to be achievable with reasonable development effort and production changes. The hydrocarbon phase-in standard is dependent on engine displacement, and will require control of HC to 5 g/km for

motorcycles between 50 cc and 170 cc. The standard increases proportionately with displacement from 5 g/km at 170 cc to 14 g/km at 750 cc. The 14 g/km level applies to all motorcycles with displacements in excess of 750 cc. Standards are also set for carbon monoxide, CO, at 17 g/km and for nitrogen oxides, NO_x, at 1.2 g/km. Of these phase-in standards, it is expected that the hydrocarbon emission levels will be the most difficult to attain. In this interim time period, the hydrocarbon controls will affect only two-stroke motorcycles. Four-stroke motorcycles presently meet the hydrocarbon standards being considered.

Long term standards are being proposed which would have to be met by the 1990 production year. Since data* indicate motorcycles are used in the urban area in a manner similar to light duty vehicles (i.e. for the purpose of transportation of persons on a street or highway), standards for motorcycle emissions are being proposed at the same level as those established for light duty vehicles. Exhaust emissions should not exceed 0.25 g/km HC, 2.1 g/km CO, and 0.25 g/km NO_x.

B. Organization of the Assessment Report

This document presents an assessment of the environmental and economic impact of the regulations EPA is planning to propose. It provides a description of the information and analyses used to review all reasonable alternative actions and to make the final selection.

* March 1974 Motorcycle Usage and Owner Profile Study, Hendrix, Tucker, & Walker, Inc. Gallup survey of motorcycle owners confirms their findings of use of motorcycles for transportation in urban areas.

This is an assessment of an air pollution control measure which is national in the scope of its effects. Consequently, the analysis is national in scope rather than site-specific. To the extent feasible, the analysis identifies differential regional impacts which result from the regulation of motorcycle air pollutant emissions.

The primary impact of these regulations will be to substantially reduce emissions of hydrocarbons and carbon monoxide from motorcycles, and to guarantee that motorcycles sold in model year 1980 and beyond will, at a minimum, meet emission standards equivalent to those for new light duty vehicles as prescribed under Section 202(b) of the Clean Air Act.

The remainder of the statement has been divided into five major sections. Chapter III presents a general description of the present in-use population of motorcycles, a projection of growth in motorcycle registrations, and a characterization of motorcycle use and scrappage patterns.

An assessment of the primary and secondary environmental impacts attributed to these regulations is given in Chapter IV. The degree of control reflected by the standards is described and a projection of air pollutant emissions for the national motorcycle population with and without the proposed standards through 1990 is presented. The impact of these regulations on total regional emissions and the expected air quality benefits are described. Secondary effects on other air pollutant emissions, water pollution, noise, and energy consumption are also discussed in this section.

Chapter V presents an assessment of the economic impact of the regulations. Included is an assessment of the impact of these regulations on producer and consumer costs (operating and first cost), and the growth and structure of the motorcycle industry.

Chapter VI discusses irreversible commitments of resources, and reviews the relationship of short term uses of the environment to long term productivity.

Chapter VII presents an evaluation of the environmental, social, and economic impacts of alternative actions including no regulation of motorcycle emissions, alternative emission standards for motorcycles and the additional reduction of emissions from other hydrocarbon and carbon monoxide sources.

Chapter III

MOTORCYCLE CHARACTERIZATION

A. Present Emissions and Fleet Description

These emission regulations are being proposed because in certain air quality regions motorcycles make a significant contribution to air pollution. With control of emissions from other vehicles in the future, a continuation of the present exception granted to motorcycles would lead to an even greater percentage contribution by motorcycles to air pollution. For example, present uncontrolled 2-stroke motorcycles emit about 12 times and 4-stroke about 2 times as much exhaust hydrocarbons as a new automobile in 1975 (see Table III-3).

The proposed regulations will affect only motorcycles designed for street use. Those motorcycles which are used exclusively "off-road" and which are not registered and equipped for street use are excluded from emission regulation.

Figure 3-1 shows the recent rapid growth in the population of registered motorcycles. Between 1960 and 1970 motorcycle registrations grew at an average rate of 17 percent per year. Over the same decade, automobile registrations grew at a rate of only 3.8 percent per year. The current population of registered motorcycles is approximately 4.9 million.* As one would expect from the nature of motorcycles, registration is not evenly distributed among all areas of the country.

* Federal Highway Administration estimate, September, 1974.

Table III-1 shows the regional variation in per capita registration of motorcycles. The number of motorcycles per 100 people is highest in the Pacific and Western regions. The number of motorcycles per 100 people has been determined for the largest 80 Standard Metropolitan Statistical Areas (SMSA's) as shown in Appendix A. The highest per capita registration is in a number of California SMSA's. The nine lowest ratios are in the densely populated and heavily trafficked Northeast Corridor SMSA's.

Emissions vary greatly between different motorcycles. Variations of different magnitudes will of course occur between different engine sizes, manufacturers, models, and engine types. The most significant variation is between two-stroke and four stroke engines. The ratio of four-stroke to two-stroke was about 60% to 40% in the 1972 registered motorcycle population. There were approximately equal numbers of each type of engine among motorcycles of less than 170 cc displacement, but four-stroke engines were more popular in motorcycles larger than 170 cc, as shown in Table III-2.

Motorcycle exhaust emission testing done by EPA and EPA contractors allows one to establish different emission characteristics for two and four-stroke engines. General emission factors are shown in Table III-3. The high hydrocarbon emissions for 2-stroke engines relative to 4-stroke is apparent. The primary reason for the high 2-stroke hydrocarbon levels is the short-circuiting of intake air-fuel mixture through the exhaust port (i.e. some of the fresh air/fuel mixture escapes through the exhaust port).
ignition.)

Table III - 1

PER CAPITA REGISTRATION OF MOTORCYCLES
BY REGION (1971)

<u>Region</u>	<u>Population (million)</u>	<u># of Motorcycles (thousand)</u>	<u># of motorcycles per 100 people</u>
Pacific	26.6	801	3.0
West	10.1	271	2.68
Midwest	54.9	896	1.6
Southwest	22.7	405	1.78
Northeast	49.1	416	0.85
South	40.4	526	1.3

Source: The Impact of Noise Abatement Standards Upon the
Motorcycle Industry, International Research and
Technology Corporation.

Table III-2

BREAKDOWN OF THE 1972 REGISTERED MOTORCYCLE POPULATION

	<u>ENGINE DISPLACEMENT</u>		
	Less than or equal to 170 cc	Greater than 170 cc	
<u>ENGINE TYPE</u> 2 Stroke	17 %	24 %	41 %
4 Stroke	18 %	41 %	59 %
	35 %	65 %	

TABLE III-3
UNCONTROLLED EMISSION FACTORS FOR MOTORCYCLES^a

Engine Type= Engine Displacement=	Emissions (grams per kilometer)				Overall ^b
	2-Stroke		4-Stroke		
	<170cc	>170cc	<170cc	>170cc	
EXHAUST HC	8.0	12.5	1.1	1.0	5.5
EXHAUST CO	9.3	22.5	9.3	22.5	20.0
EXHAUST NO _x	0.03	0.05	0.14	0.10	0.8
CRANKCASE HC ^c	- - -	0.0	- - -	- - -0.4-	0.25
PARTICULATES	- - -	0.21	- - -	- - -0.03	0.10
SULFUR OXIDES ^d	- - -	0.024	- -	- - -0.014	0.018
EVAPORATIVE HC ^e	- - - - -	1360 grams per year - - - - -			

- These emission factors are based on the results of EPA in-house testing (Feb-June 1974) and contractor testing (Southwest Research Institute; "Exhaust Emissions from Uncontrolled Vehicles and Related Equipment Using Internal Combustion Engines, Part III: Motorcycles"; March 1973).
- Weighted on the basis of kilometers travelled in each category.
- Most 2-stroke engines use crankcase induction and produce no crankcase losses.
- Calculated using a 0.043 percent sulfur content (by weight) for regular fuel used in 2-stroke engines and 0.022 percent sulfur content (by weight) for premium fuel used in 4-stroke engines.
- Evaporative emissions were calculated assuming that carburetor losses were negligible. Diurnal breathing of the fuel tank (a function of fuel vapor pressure, vapor space in the tank, and diurnal temperature variation) was assumed to account for all the evaporative losses associated with motorcycles. The value presented is based on average vapor pressure, vapor space and temperature variation.

The contribution that motorcycles make towards pollutant levels in a given urban area depends on the size of the motorcycle population, the breakdown of the population by engine size and type, and the number of miles that the motorcycle population is driven. This will be discussed in detail in Section IV.

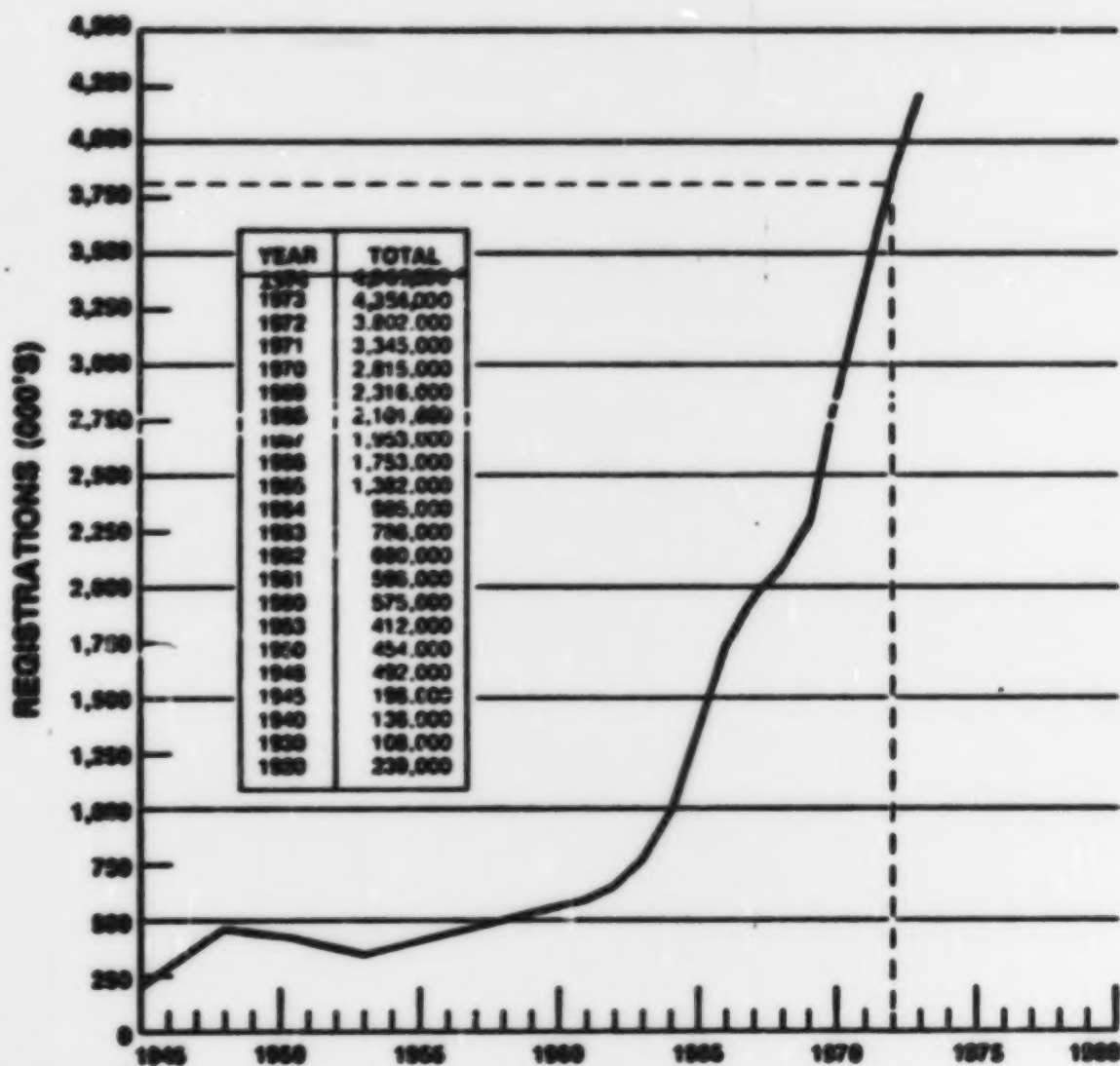
B. Projected Growth in Motorcycle Registrations

Figure 3-1 shows the historical progression of new motorcycle registrations. Both new registrations and the total population of registered motorcycles have recently experienced very rapid growth. Between 1967 and 1970, new registrations (which approximate sales of new on-road motorcycles) grew at a very rapid 38.0 percent per year. From 1970 to 1974 the growth rate slowed to an average rate of 8.0 percent per year. New registrations in 1974 dropped 14 percent from the 1973 level.* In projecting the population of motorcycles, the exceptional growth rate in sales and total population of the late 1960's should not be extrapolated to the 1980's because the market is likely to change in nature greatly from those years. A number of factors need to be considered when projecting motorcycle sales and the registered population; these are briefly outlined below. Some of these factors are positive influences on the growth in sales, while others are negative influences on sales. In arriving at a growth estimate, it is necessary to take into account the strength of these various factors.

* Motorcycle Industry Council estimates new registrations at 1.19 million in 1973, and 1.02 million in 1974.

Figure 3-1

TOTAL U.S. MOTORCYCLE REGISTRATIONS BY YEAR



Source: Motorcycle Industry Council

* Estimate

The price of the product has experienced very rapid increases recently. Almost 90 percent of the motorcycles sold come from Japan and the extremely rapid rises in cost of oil, steel and labor in the Japanese economy has greatly affected the price of motorcycles sold in the United States. A continuation of current Japanese economic trends could lead to rapidly increasing motorcycle prices relative to American price indices. Large increases in the initial purchase price for motorcycles imply reductions in demand. Price increases may make the motorcycle less attractive as transportation when compared to the automobile. Rapidly increasing insurance costs represent an operating expense which will also tend to discourage new sales. No-fault insurance could lead to rapidly rising premiums in the short run, but new safety regulations and rider education programs could cause a levelling-off of insurance premiums in the 1980-1990 time frame.

Shifts in population age groups represent an important factor in any evaluation of the future growth of sales relative to historical trends. For motorcycle sales, the size of the age group from 20-34 is most important for on-road motorcycles. Off-road motorcycles are dependent on sales to the younger, 16-24, age group. As can be seen in Table III-4, the annual growth rate of the 20-34 age group from 1972 to 1980 is expected to average a rapid 3 percent per year. This rate slows to a rate of growth of 1.1 percent per year from 1980-1985. These rates of growth are a good indicator of more rapid growth of motorcycle sales in the short run (to 1980), with less rapid growth after 1980. Sales are expected to increase faster than the national growth rate of just this one age group, however.

TABLE III-4
POPULATION BY AGE GROUP, 1960-72, PROJECTIONS TO 1980, 1985

	Number of People (millions)			Average Annual Percent Increase 1972-80 1980-85	Percent Distribution					
	1960	1972	1980	1985	1960	1972	1980	1985		
Under 16	58.9	60.9	56.8	60.0	0.8	1.1	32.6	29.2	25.4	25.5
16-19	10.7	15.9	16.4	14.0	0.4	3.2	5.9	7.6	7.3	6.0
20-34	34.0	45.6	58.0	61.2	3.0	1.1	18.8	21.8	25.9	26.0
35-54	44.8	46.4	47.8	53.2	0.4	2.1	24.8	22.2	21.3	22.5
55 and over	32.3	40.0	45.1	47.3	1.5	1.0	17.9	19.2	20.1	20.0
TOTAL	180.7	208.8	224.1	235.7	0.9	1.0	100.0	100.0	100.0	100.0

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SOURCE: Bureau of Labor Statistics Review, December 1973.

Certain regional markets, such as the South and Southwest, will grow more rapidly than the national average due to the present low per capita registrations in these areas.^{1/}

Considerations of safety have somewhat dampened the growth in popularity of motorcycles from the late 1960's. Motorcycles are a relatively less safe form of on-road transportation with a fatality rate almost four times greater than that for automobile drivers and passengers.^{2/} Safety is a crucial issue in the motorcycle industry, and a vigorous safety campaign by a government agency or a consumer group could have a negative impact on demand.

Because motorcycling is partly a recreational activity, it will be affected by a number of forces related to the demand for recreation. A trend towards an increasingly shorter work week and the positive effect this has on sales of recreational products implies a rate of growth in sales which is greater than the growth rate in population. Higher income groups, with their greater discretionary incomes, are large purchasers of motorcycles. Trends towards fewer children per family suggest increases in discretionary incomes, with a positive effect on new registrations. The vast untapped female market provides a possibility for a growth rate for motorcycles which exceeds the growth rate of population.

^{1/} The Impact of Noise Abatement Standards Upon the Motorcycle Industry, IR&T Corp.

^{2/} Based on National Safety Council Statistics: in 1972 deaths per one hundred million miles traveled were 4.7 for all motor vehicles and 18.0 for motorcycles only.

A massive shift in the role of motorcycles as transportation in the United States could imply an extremely high growth rate of motorcycle sales. The fuel economy advantages offered by this product will provide a definite positive stimulus to demand. However, a massive shift to motorcycles as a form of basic transportation for a large percentage of the U.S. population seems unlikely for several reasons. Such basic product characteristics as exposure to climate, limited carrying capacities, risk of operation, and the coordination required for operation will limit the potential for mass use as a transportation vehicle. A trend towards manufacture of compact and sub-compact cars by Detroit will be likely to provide a more attractive substitute to motorcycles for many who desire economical transportation. As a transportation vehicle, motorcycles can be expected to increase in popularity with rapid increases in fuel costs. However, this possibility should not be overstated for the reasons outlined above.

The activities of the large manufacturers of motorcycles suggest that they do not view the American market as having the potential it had in the late 1960's for extremely rapid growth. They are actively committing their resources to developing alternative markets in Africa, South America and the Middle East. The American market is certainly not saturated, however.

While recent slumps in sales may be an indication of factors at work besides short-term economic conditions, it is felt that there is still potential for considerable growth in sales of motorcycles. It is estimated that 1975 sales could be lower than 1974 sales, and that at best they will equal 1974 levels. It is assumed here, based on an evaluation of both the positive and negative factors influencing growth,

that the market responds in 1976 and resumes a 1970-1974 growth rate of 8 percent per year. This growth rate is expected to continue until 1980 when there will be a decrease in the growth rate to about 4 percent per year through the 1980's. Annual new and total registrations through 1990 implied by these growth rates and historical data on motorcycle scrappage rates are shown in Table III-5.

C. Motorcycle Usage

In order to project the impact of new motorcycle emission standards on in-use motorcycle emissions, one must characterize the present in-use population of motorcycles, estimate present and future annual mileage for motorcycles, and estimate the rate at which existing motorcycles will be scrapped and newer, cleaner ones will come into use.

The Motorcycle Industry Council (MIC) commissioned the Gallup Organization to perform a survey of motorcycle owners. In 1974 the Gallup Organization surveyed over 4100 motorcycle owners. The data derived in the survey were then weighted according to the distribution of motorcycle ownership in the country, giving 9888 weighted responses. The EPA received a tape of the survey data, from which usage and scrappage rates were obtained.

Based on these data the average life of a motorcycle between 50 and 170 cc is about 12,000 kilometers and for motorcycles greater than 170 cc the average life is over twice as large, about 30,000 kilometers. As shown in Table III-6, usage is greatest in the early years of ownership, tapering off as the vehicle becomes older.

TABLE III-5
PROJECTED NEW REGISTRATIONS OF
MOTORCYCLES THROUGH 1990

<u>Year</u>	<u>New Registrations</u> <u>(millions of units)</u>	<u>Percent Increase</u> <u>over Previous Year</u>	<u>Total Registrations</u> ^{2/} <u>(millions of units)</u>
1974	1.01 ^{1/}	--	4.99
1975	1.01	0	5.37
1976	1.09	8	5.82
1977	1.17	8	6.26
1978	1.27	8	6.72
1979	1.37	8	7.17
1980	1.43	4	7.57
1981	1.49	4	8.06
1982	1.55	4	8.57
1983	1.60	4	9.10
1984	1.67	4	9.56
1985	1.73	4	9.98
1986	1.81	4	10.39
1987	1.88	4	10.82
1988	1.96	4	11.28
1989	2.03	4	11.76
1990	2.12	4	12.26

1/ Based on R. L. Polk data on New Registrations, baseline without proposed regulations.

2/ Based on the New Registrations and historical data on rates of scrappage of in-use motorcycles in the next section on motorcycle use.

Table III-6

MOTORCYCLE USAGE BY AGE AND SIZE
(kilometers per year)

<u>YEAR</u>	<u>LESS THAN 170 CC</u>	<u>GREATER THAN 170 CC</u>
1	3475	6986
2	1945	3902
3	1817	3788
4	1677	3670
5	1541	3554
6	1408	3438
7	1273	3322
8	1139	3208
9	1004	3091
10	870	3047
11	734	2850
12	602	2743
13	465	2627
14	331	2510
15	198	2396

Turn-over of the motorcycle population (scrappage) is important to assessing control effectiveness as this determines the rate at which new air pollution controlled motorcycles replace the older high emitting ones out on the road. The Gallup survey and motorcycle registration data indicate an average scrappage rate of 15 percent overall. Estimates of the likelihood of motorcycle survival in the in-use population each year after purchase are shown in Table III-7. The average life of a motorcycle of less than 170 cc is about 5.5 years. Average life of motorcycles greater than 170 cc is 7.3 years.

Table III-7

ASSUMED PROBABILITY OF SURVIVAL
IN-USE POPULATION OF MOTORCYCLES

<u>YEAR</u>	<u>LESS THAN 170 cc</u>	<u>GREATER THAN 170 cc</u>
1	1.00	1.00
2	1.00	.95
3	.74	.85
4	.62	.70
5	.46	.66
6	.41	.66
7	.53*	.70
8	.20	.33
9	.20	.25
10	.12	.13
11	.05	.32
12	.02	.30
13	.03	.25
14	.03	.12
15	.01	.03

* FLUCTUATION(s) ARE DUE TO VARIABILITY IN THE DATA SAMPLE

Chapter IV

ENVIRONMENTAL IMPACT

A. Primary Impact

1. Emissions Reductions for In-Use Motorcycles

As shown in Table IV-1, the proposed emissions standards, if met through the life of the motorcycle, will decrease hydrocarbon and carbon monoxide emissions from motorcycles sold in model years 1978 and 1979 by 20 to 30 percent. The 1980 standards will reduce CO and HC exhaust emissions by about 90 percent. Exhaust emissions of nitrogen oxides, which are inherently low, will increase somewhat but remain low as hydrocarbons and carbon monoxide are controlled. Nitrogen oxide emission standards will guarantee, however, that the increase never exceeds the levels required for light duty vehicles, and insure that nitrogen oxide levels are compatible with nitrogen dioxide air quality control strategies.

Evaporative emission standards for motorcycles are not a part of the proposed regulations. Motorcycle evaporative emissions are presently relatively small compared to motorcycle exhaust emissions but may eventually prove to be significant. Proposal of limitations on evaporative emissions may occur at a later date if a need is established and once the appropriate test procedures and standards have been developed.

Two-stroke motorcycles by their design have no direct venting of crankcase gases. Four-stroke crankcase emissions will require complete control starting in 1978.

TABLE IV-1
ESTIMATED DEGREE OF CONTROL
FOR PROPOSED EMISSION STANDARDS

Engine Type =	Two Stroke		Four Stroke		Overall ^a
Engine Displacement=	<170cc	>170cc	<170cc	>170cc	
EXHAUST HC					
1978	386	356	66	66	306
1980	976	986	776	866	956
EXHAUST CO					
1978	66	256	66	256	226
1980	776	916	776	916	906
EXHAUST NO_x					
1978	- - - - - Increase Somewhat ^b - - - - -				
1980	- - - - - Increase Somewhat- - - - -				
EVAPORATIVE HC					
1978	- - - - - NA ^c - - - - -				
1980	- - - - - NA - - - - -				
CRANKCASE HC					
1978	- - - -	NA ^d - - - -	1006		1006
1980	- - - -	NA - - - -	1006		1006

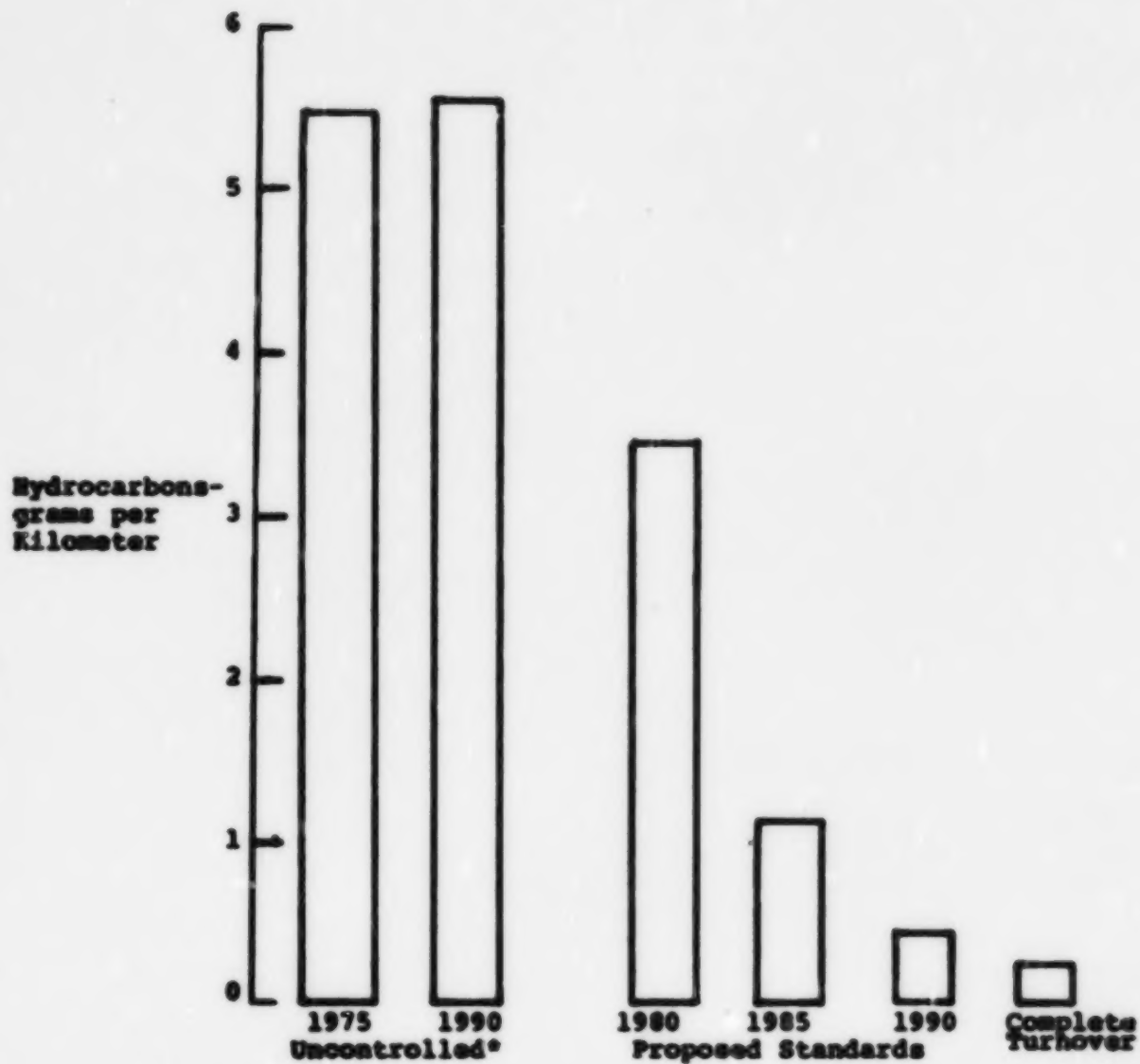
- Weighted by miles travelled.
- Always at or below automobile levels.
- Evaporative emission standards not being proposed at this time. Test procedure under development.
- Two-stroke engines use crankcase induction and have no crankcase emissions.

As new motorcycles are put into use and older ones are scrapped, emissions of the "average" motorcycle on the road will decrease. Using the sales projections, usage data, and vehicle survival data in Tables III-5, III-6, and III-7, emissions of HC, CO, and NO_x from the total in-use population of motorcycles have been projected. Figures 4-1, 4-2 and 4-3 show the average emissions of HC, CO and NO_x from a motorcycle on the road in 1980, 1985 and 1990 under the proposed standards. Values are weighted on the basis of miles traveled by motorcycles from each model year still on the road in the year considered. Hydrocarbon and carbon monoxide emissions drop off quickly in the 1980's, while nitrogen oxide levels hold relatively constant at about 0.25 grams per kilometer throughout the 1980's. This constancy is due to levels of about 0.6 grams per kilometer in model years 1978 and 1979.

Nationwide total emissions of exhaust HC, CO and NO_x from motorcycles are projected through 1990 with and without the proposed regulations in effect in Figures 4-4, 4-5 and 4-6. One can see that the control standards will be effective in reducing both the average motorcycle and absolute motorcycle emissions of HC and CO. Nitrogen oxide emissions which were inherently very low prior to control increase by about four fold between 1977 and 1990. These levels still reflect levels of emission equivalent to the lowest NO_x emission level proposed for automobiles.

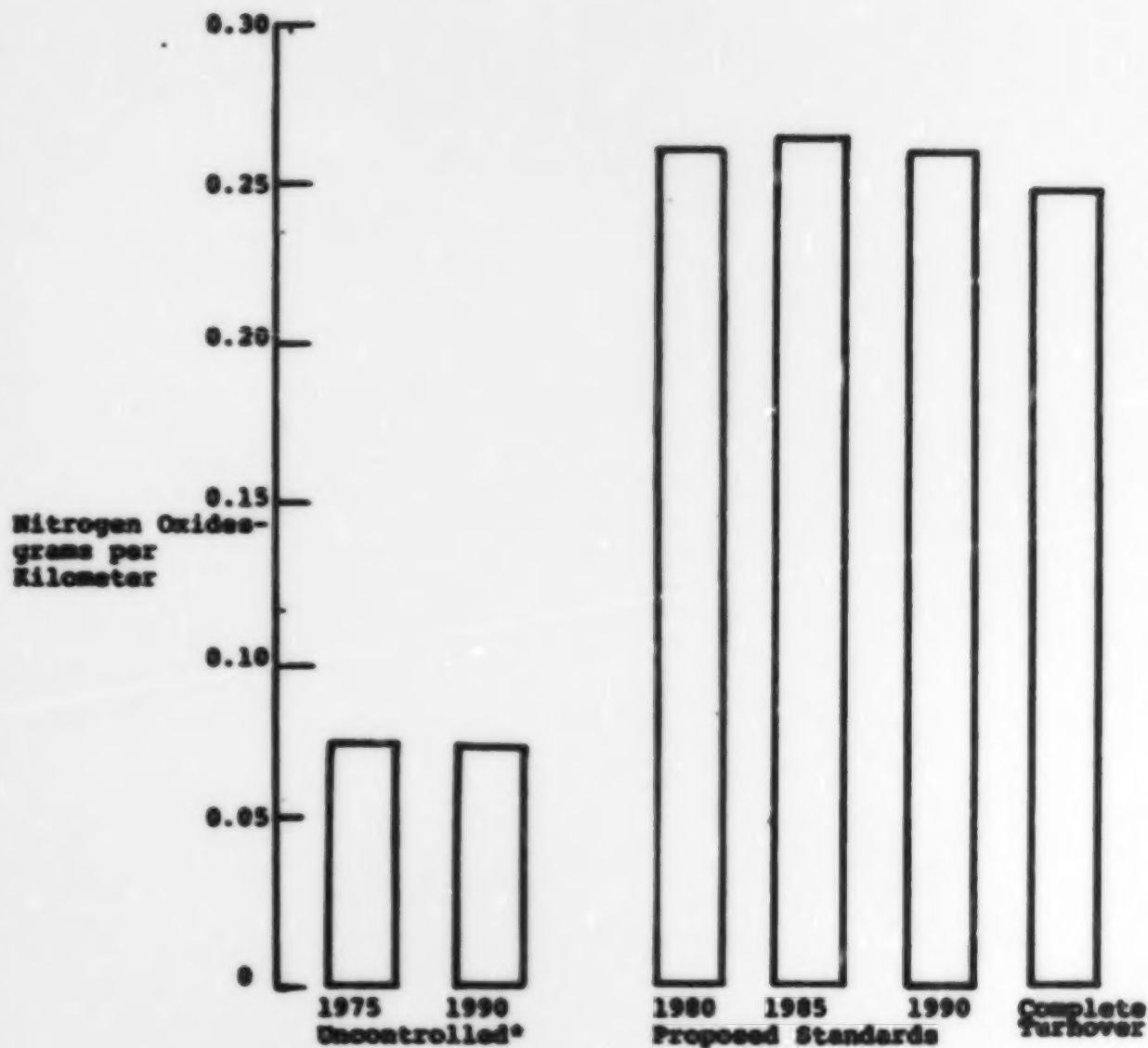
It should be noted that the reductions in emissions projected in this analysis assume that controlled motorcycles will meet the applicable emission standards over their life. Whether this actually happens depends largely on the extent to which the motorcycle manufacturer and EPA are able to determine how proposed emission control system designs will operate in actual use, the good-faith of the manufacturer in choosing and producing effective and durable emission control system designs, and the

Figure 4-1
AVERAGE "ON THE ROAD" EMISSION FACTORS
FOR MOTORCYCLE EXHAUST HYDROCARBONS



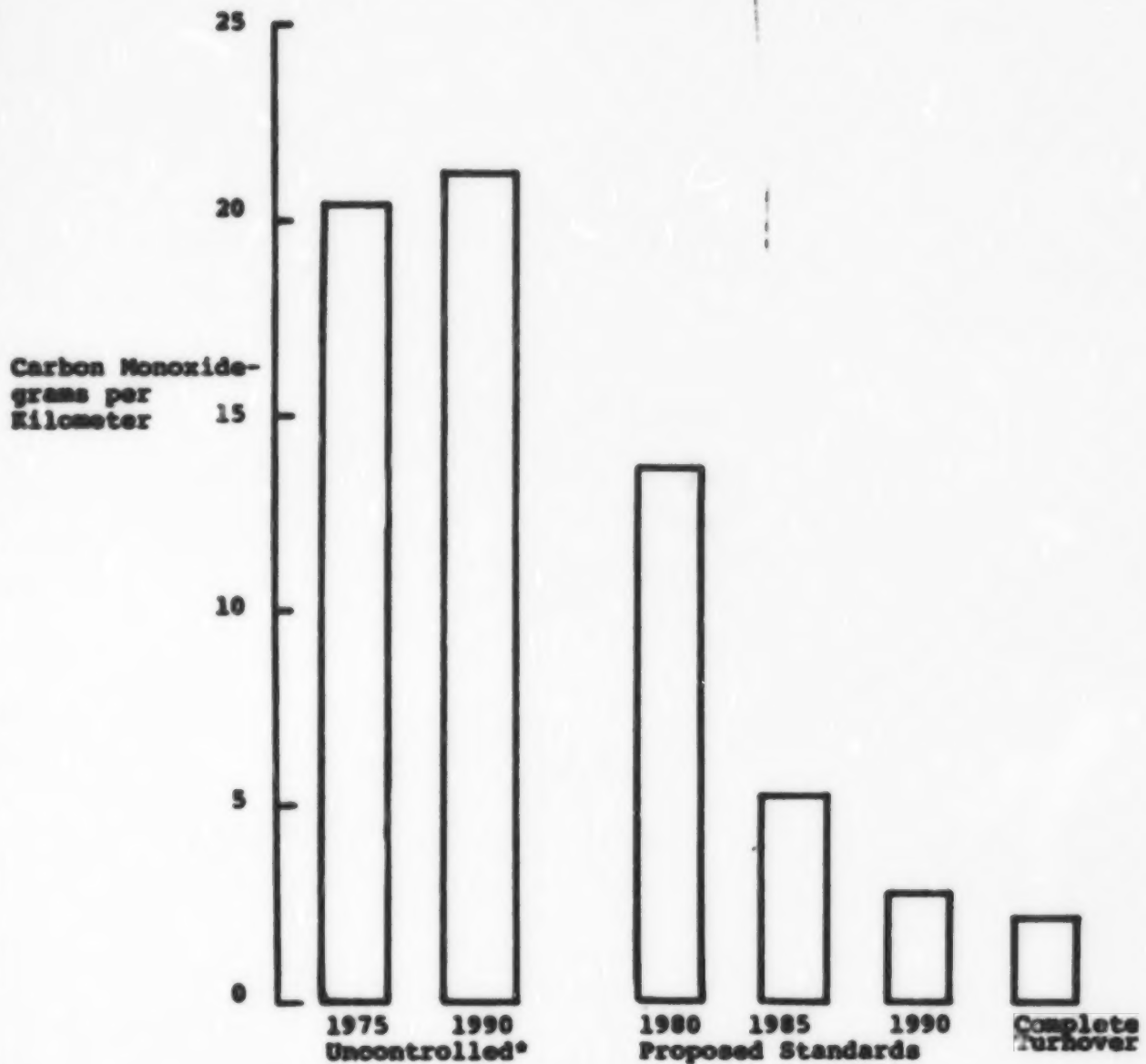
* Slight shifts due to move to larger motorcycles.

Figure 4-2
AVERAGE "ON-THE-ROAD" EMISSION FACTORS
FOR MOTORCYCLE NITROGEN OXIDE EXHAUST



* Slight shifts due to move to larger motorcycles.

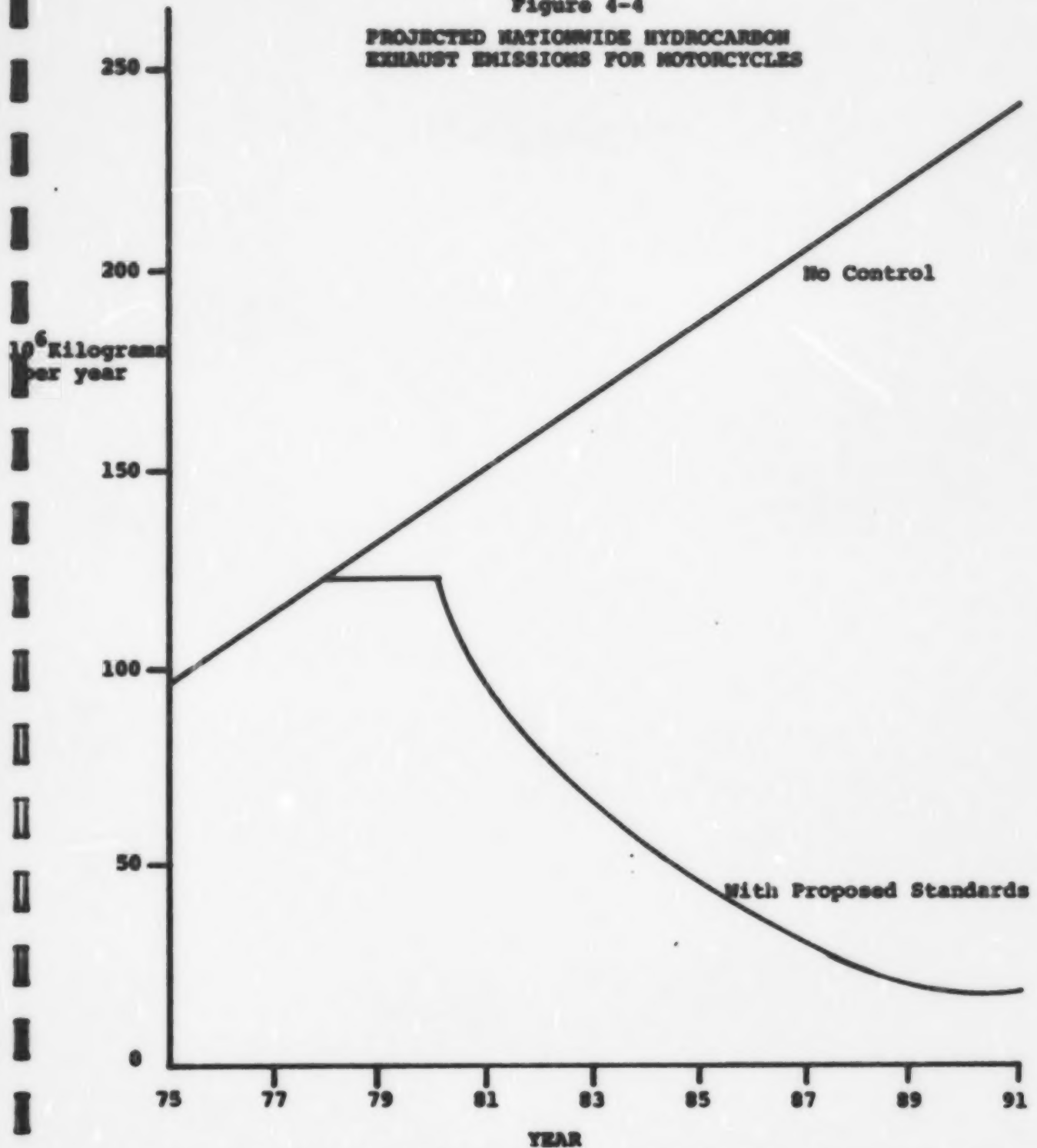
Figure 4-3
AVERAGE "ON THE ROAD" EMISSION FACTORS
FOR MOTORCYCLE EXHAUST CARBON MONOXIDE



* Slight shifts due to move to larger motorcycles.

Figure 4-4

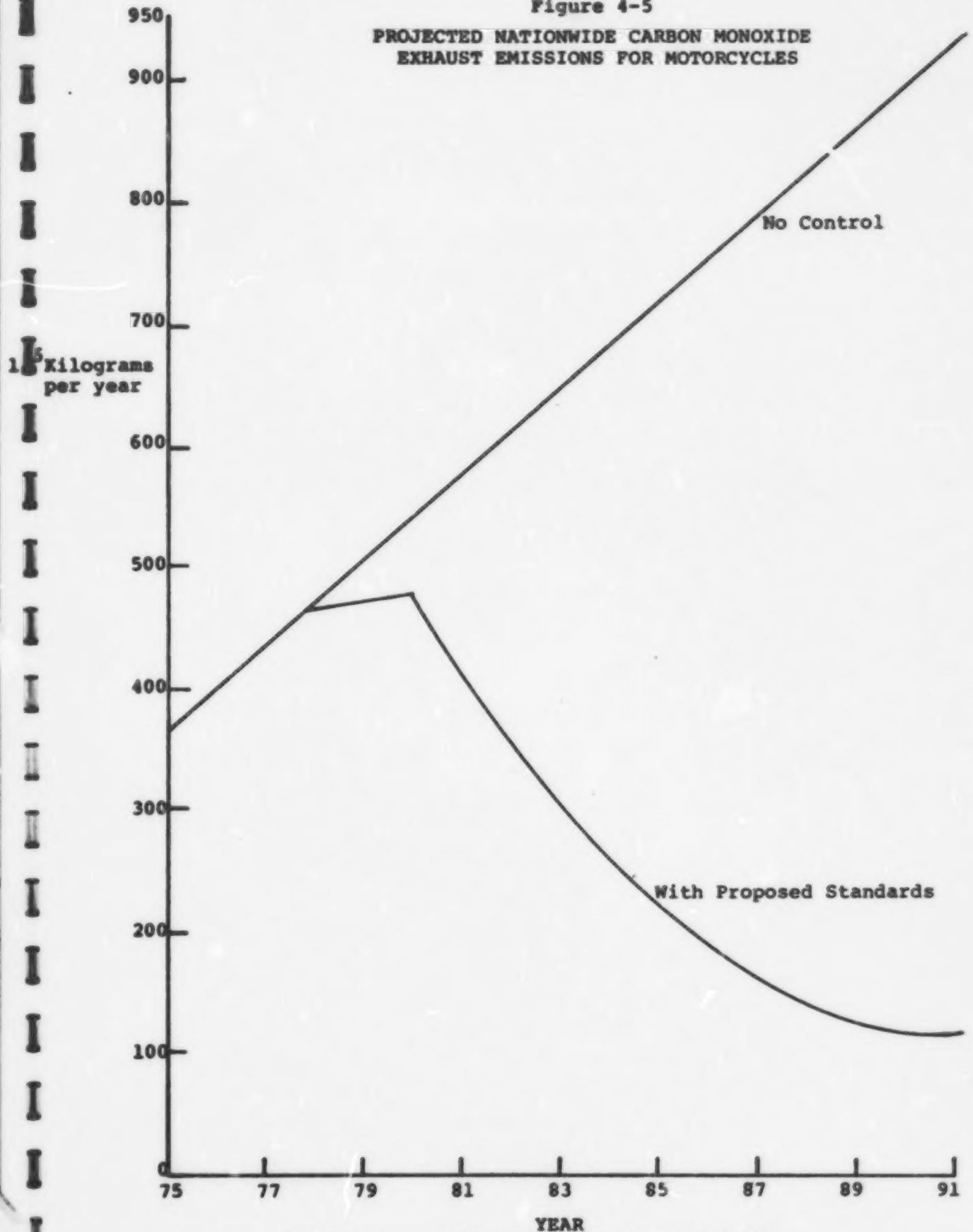
PROJECTED NATIONWIDE HYDROCARBON
EXHAUST EMISSIONS FOR MOTORCYCLES



Source: Energy and Environmental Analysis, Inc. Motorcycle Emissions
Projection Model

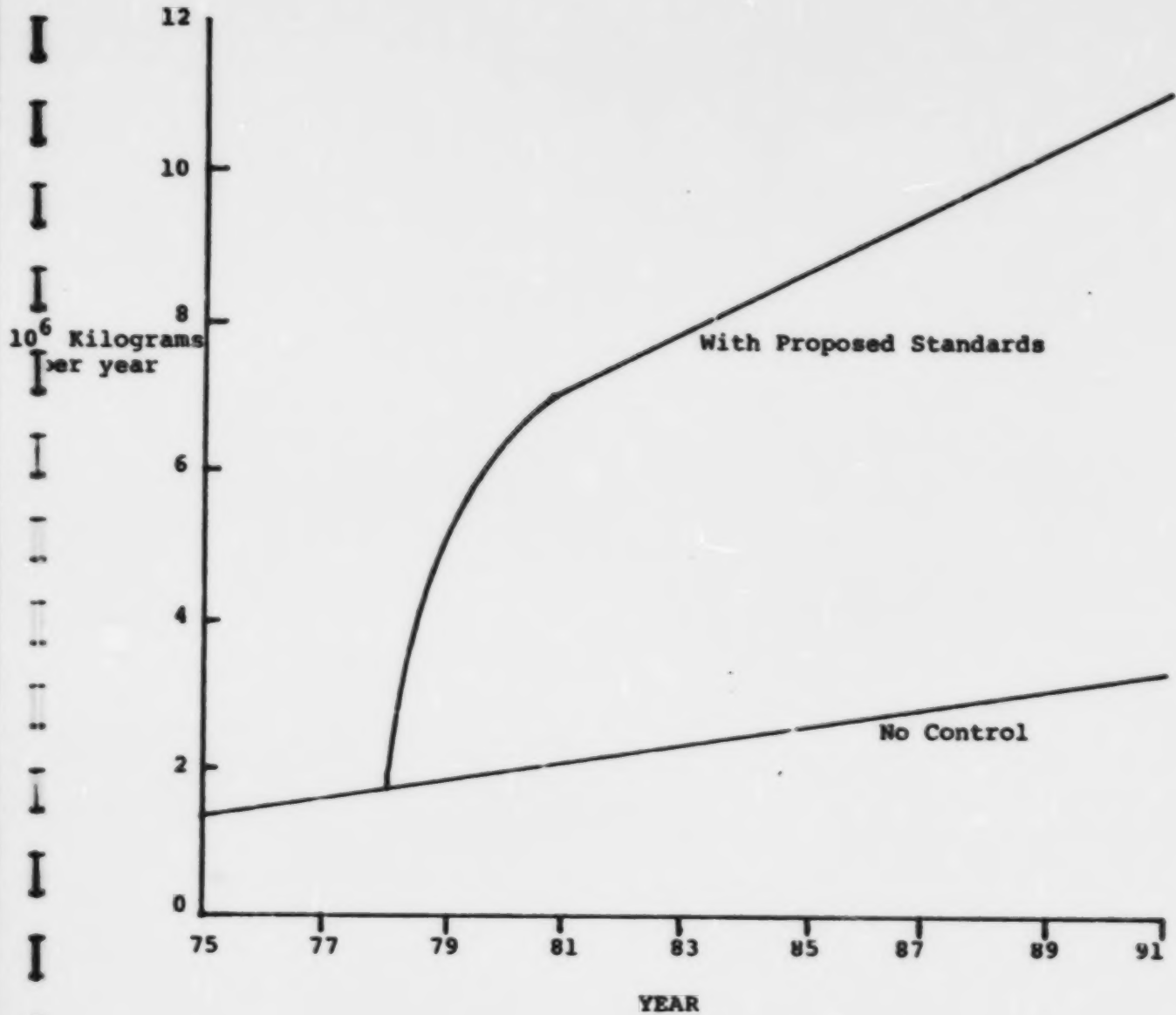
Figure 4-5

PROJECTED NATIONWIDE CARBON MONOXIDE
EXHAUST EMISSIONS FOR MOTORCYCLES



Source: EEA Motorcycle Emissions Projection Model.

Figure 4-6
PROJECTED NATIONWIDE NITROGEN OXIDE
EMISSIONS FOR MOTORCYCLES



Source: EEA Motorcycle Emissions Projection Model.

extent to which motorcycle users properly use and maintain their motorcycles. The latter is of concern since EPA's certification program only provides some assurance that the emission control system design is capable of meeting the standards over the useful life of the motorcycle if the motorcycle is properly used and maintained. To ensure that motorcycles are properly maintained will require other enforcement programs such as the in-use vehicles emissions inspection/maintenance programs included in many state transportation control plans. There is presently insufficient information on the deterioration of emission control systems on motorcycles over mileage accumulation, the maintenance practices of the average motorcycle owner, and how such practices affect motorcycle emissions, to quantify the extent to which in-use motorcycles would exceed the standards without inspection/maintenance and/or other enforcement programs. Thus, for the purposes of this analysis, motorcycles are assumed to meet the standards throughout their lives. Also, since the costs of inspection/maintenance for motorcycles is not known at this time, and would vary by state, those costs are not reflected in this analysis.

2. Estimated Impact of Motorcycle Emissions on Regional and National Total Emissions

Inventories of air pollution sources and the amount of air pollution released by each are used to project future emissions and air quality. These inventories, in most cases, do not explicitly examine the contribution of motorcycles. Motorcycles are normally covered by aggregate emission factors related directly to fuel consumption in the region. Such aggregate estimates are not adequate for assessing the individual role of motorcycles in achieving or not achieving sufficiently low pollutant emissions and thereby acceptable levels of air quality.

Motorcycle emissions have, however, been explicitly examined in the development of air quality implementation

plans for regions in California and Arizona. Table IV-2 shows the projected levels of reactive hydrocarbon emissions in 1977 for Los Angeles, Sacramento and San Francisco. Even with strict control of emissions from automobiles and stationary sources, these regions are not expected to achieve the oxidant air quality standard under a reasonable control scenario. From the table, one can see that in these areas where motorcycle use is popular, motorcycles will contribute 3 to 5 percent of the total hydrocarbon emissions in 1977. If left uncontrolled, motorcycle emissions could easily climb to over 10 percent of total emissions of HC in California problem areas.

Table IV-3 shows projected emission inventories for 1977 and 1980 for the Phoenix-Tucson region. As with the California regions, motorcycles are expected to contribute about 5 percent of the total hydrocarbon emissions in the late seventies. The percentage contribution to carbon monoxide emissions is also on the order of five percent. If motorcycle emission controls are not implemented, one can expect that motorcycle emissions will continue to grow and become a larger portion of the total emission inventory.

On a nationwide basis, motorcycle contribution is not as great as the levels shown in Tables IV-2 and IV-3 because these emission inventories represent areas of relatively high motorcycle use and include transportation control measures yet to be implemented. An estimate of the nationwide percent contribution of motorcycle emissions controlled and uncontrolled is presented in Table IV-4. The analysis is based on the projection of total emissions from motorcycles presented in Figures 4-4, 4-5 and 4-6 and a recent EPA analysis of the long-term effectiveness of overall control strategies for CO, HC, and NO_x entitled "Air Quality Impact of Alternative Emission Standards for Light Duty Vehicles", dated March 12, 1975. The background information used to generate the projections is given in Appendix B. The projection indicates that motorcycles, if left uncontrolled,

TABLE IV-2
ASSESSMENT OF MOTORCYCLE
HYDROCARBON EMISSIONS IN THE CONTEXT
OF CALIFORNIA PLANS TO REDUCE
PHOTOCHEMICAL OXIDANTS IN 1977^a

	Projected Emissions of Reactive Hydrocarbons ^b , Tons per Day, 1977		
	Los	San	
	Angeles	Francisco	Sacramento
Emissions in 1977 without local Control Measures	849.	426.	94.8
Reductions Anticipated with Local Control Measures			
• Gasoline Vapor Control	-132.	-138.	-26.0
• Solvent Control	-32.	-37.	- 3.7
• Open Burning Limits			- 2.1
• Auto Use Reductions	-61.	-14.	- 1.7
• Auto Inspection and Control Retrofits	-103.	-33.	- 9.9
Remaining Emissions, 1977	521.	204	51.4
Total Emissions Allowed to Meet Oxidant Std.	112.	125.	34.5
Motorcycle Contribution	24.	6.	2.0
Percent of Total	54	36	40
Percent of Allowed Level	210	50	60

a. Emission data extracted from EPA Transportation Control Plans for California.

b. "Reactive" Hydrocarbons described in Section IV-B-3.

TABLE IV-3
PHOENIX-TUCSON AIR QUALITY CONTROL REGION EMISSIONS
INVENTORIES FOR 1977 and 1980*

	HYDROCARBONS (tons/day)		CARBON MONOXIDE (tons/day)	
	<u>1977</u>	<u>1980</u>	<u>1977</u>	<u>1980</u>
Light Duty Vehicles	19.1	14.1	236	183
Heavy Duty Vehicles	6.2	6.7	73	87
Motorcycles (Uncontrolled)	3.5	4.6	17	19
Aircraft	11.7	12.9	29	31
Stationary Sources	<u>46.9</u>	<u>55.7</u>	-	-
TOTAL	87.4	94.0	355	320
Motorcycle % of Total	4%	5%	5%	6%

- * Transportation control plan in effect includes reduction in "vehicle miles travelled", inspection and maintenance and major retrofit program.

Table IV-4

PROJECTED MOTORCYCLE CONTRIBUTION TO NATIONWIDE EMISSIONS

% CONTRIBUTION TO EMISSIONS

MOTORCYCLE EXHAUST EMISSIONS	1970		1980		1990	
	Mobile Sources	Total Emissions	Mobile Sources	Total Emissions	Mobile Sources	Total Emissions
Hydrocarbons						
Controlled	—	—	0.7%	0.43%	0.15%	.09%
Uncontrolled	0.22%	0.15%	1.2%	0.68%	2.5%	1.3%
Carbon Monoxide						
Controlled	—	—	0.86%	0.81%	0.47%	0.42%
Uncontrolled	0.17%	0.17%	1.41%	1.33%	3.71%	3.3%
Nitrogen Oxides						
Controlled	—	—	.103%	.041%	0.22%	.067%
Uncontrolled	.008%	.004%	.030%	.012%	.063%	.019%

would account for 1.3 percent of total hydrocarbon emissions and 3.3 percent of total carbon monoxide emissions by 1990. Taking into account the uneven distribution of the United States motorcycle population (concentrated in the West), and the uneven distribution of usage over the year (concentrated in the summer), uncontrolled motorcycle emissions in 1990 could account for up to 10 percent of CO or HC emissions during adverse air quality conditions in certain areas of the United States. The proposed emission regulations will bring the contribution of motorcycles to total CO and HC emissions back within the range observed in 1970, less than 0.5 percent.

Nitrogen oxide emissions, in spite of a four-fold increase due to control of HC and CO, will remain below 0.07% of total NO_x emissions and below 0.3% of total mobile source emissions in 1990.

3. Areas Affected by Motorcycle Emission Regulations

Any and all regions of the United States which are not meeting air quality standards for carbon monoxide and photochemical oxidants will benefit in some way from these control standards, as they will serve as one of many strategies to help reduce overall emissions of HC and CO and thereby improve air quality. On the other hand, areas which are not in compliance with the nitrogen dioxide standard will receive a small disbenefit due to these standards, although the contribution on the benefit side (in % reduction of overall emissions) is an order of magnitude larger than the disbenefit related to the NO_x emissions increase.

Two key indicators can be used to identify the regions which benefit most from these regulations: (1) the projected ability of various regions to achieve air quality standards, (2) level (concentration) of motorcycle use in the various regions. Table

IV-3 gives the results of a recent EPA analysis of potential for meeting air quality standards for oxidants, carbon monoxide and nitrogen dioxide.* The potential for attainment and maintenance of the air quality standards is not great for the major population centers of the United States. About one third of the U.S. population lives in areas which are projected to have problems meeting air quality standards in 1985.

The magnitude of any benefit (or disbenefit) is difficult to define. Simplistic analyses normally assume emissions reductions yield proportional air quality improvements for CO and NO₂. For oxidants, a nonlinear relationship with HC emissions is frequently used. In actuality emissions impact on air quality is very much a function of the time, location and intensity of emissions. These factors cannot, however, be adequately accounted for on a nationwide basis. Generally speaking the CO and HC benefits should be on the order of one to three percent improvement in air quality in the 1985 time frame.

Benefits will generally be greater in areas where motorcycle populations are densest. Table IV-6 shows a listing of all regions which have a motorcycle density of over two vehicles per 100 persons. Most of these regions are in the West, Southwest and South. Cross referencing this list with the list of regions having trouble meeting air quality standards in 1985 gives a good indication of the areas which will benefit most from motorcycle emissions control. Table IV-7 shows those regions having a high motorcycle population density and which are likely to have air quality problems in 1985. Six of the nine regions are in California. The remaining three, Denver, Phoenix-Tucson and Wasatch Front (Salt Lake City) are all in the West. Over 20 million people now reside in the identified areas.

- * The ambient air quality standards for these pollutants have been set by EPA at levels designed to insure adequate public protection from these pollutants. The effects of hydrocarbons, carbon monoxide, nitrogen oxides, and a product of atmospheric reactions of HC and NO_x, namely oxidants, have been considered and described in a series of EPA criteria documents on these pollutants - Air Pollution Control Office Publications AP-62, AP-63, AP-64 and AP-84.

TABLE IV-5
REGIONS OF THE U.S. PREDICTED TO HAVE
AIR QUALITY PROBLEMS IN 1985

NITROGEN
DIOXIDE

Los Angeles
Chicago
NY-NJ-Conn
Denver
Philadelphia
Wasatch Front
Baltimore
National Capitol

CARBON
MONOXIDE

Phoenix-Tucson
Wasatch Front
NY-NJ-Conn.
North Alaska
Los Angeles

PHOTOCHEMICAL
OXIDANTS

Los Angeles
S. E. Desert
Houston-Galveston
National Capitol
San Francisco
San Joaquin
Sacramento Valley
San Diego
S. E. Texas
Phoenix-Tucson
Denver
Corpus-Christi
NY-NJ-Conn.
Clark-Mohave
Dayton
S. W. Penn.
Birmingham
Philadelphia
Boston
Cincinnati
Indianapolis
Genesee-Finger Lakes
San Antonio

Present populations in these
areas (approximate)

NO _x	≈ 30 million
CO	≈ 20 million
OXIDANT	≈ 68 million
OVERALL	≈ 75 million

Source: "Air Quality Impact of Alternative Emission Standards for
Light Duty Vehicles," OAMM, EPA, March 12, 1975 revision.

TABLE IV-6
REGIONS HAVING MOTORCYCLE DENSITIES
OF OVER 2 PER HUNDRED PERSONS

<u>REGIONS</u>	<u>NUMBER OF MOTORCYCLES PER 100 PEOPLE</u>
San Joaquin	3.5
S. E. Desert	3.5
Wichita	3.5
Wasatch Front	3.5
Sacramento	3.4
San Diego	3.3
Albuquerque	3.0
Los Angeles	3.0
Tulsa	2.9
Oklahoma City	2.9
Jacksonville	2.9
Lansing	2.9
Portland	2.8
San Francisco	2.8
Grand Rapids/Flint	2.6
Phoenix-Tucson	2.5
Denver	2.4
Dallas-Ft. Worth	2.3
West Palm Beach	2.3
Seattle	2.2
Omaha	2.2

Source: Derived from Appendix A.

TABLE IV-7
AREAS HAVING BOTH HIGH MOTORCYCLE OWNERSHIP
AND FUTURE AIR QUALITY PROBLEM POTENTIAL IN 1985

	<u>Pollutant(s)</u>	<u>Present Population (millions)</u>
San Joaquin	Ox ^a	1.7
S. E. Dessert	Ox	0.3
Wasatch Front	CO, NO ₂	0.9
Sacramento	Ox	0.7
San Diego	Ox	1.4
Los Angeles	Ox, CO, NO ₂	10.3
San Francisco	Ox	3.4
Phoenix-Tucson	Ox, CO	1.4
Denver	Ox, NO ₂	<u>1.2</u>
		21.3 million

Ox = Photochemical oxidants

B. Potential Secondary Environmental Impacts of the Proposed Regulations

1. Sulfate Emissions

If catalytic converters are selected for emission control in the post-1980 period, the potential exists for increased emissions of sulfuric acid aerosol from motorcycles.

Sulfur impurities in gasoline range from 50 to 1000 ppm averaging 300 ppm of sulfur. In a non-catalyst controlled vehicle, most of the sulfur leaves the vehicle as SO_2 . The present oxidation catalyst systems used on automobiles increase the conversion to SO_3 which in turn combines with water in the exhaust to form sulfuric acid aerosol.

The increase in sulfate emissions due to use of the oxidation catalyst has been of considerable concern to EPA regarding automotive control systems. An emission control program for automotive sulfates is presently being developed by EPA for implementation in automotive model year 1979.

However, sulfate emissions from motorcycles are not likely to present a future problem for several reasons:

- Present information on sulfate emissions indicates that sulfate emissions are proportional to fuel consumption -- all other things being equal. The relative magnitude of potential motorcycle sulfate emissions based on overall fuel consumption figures for automobiles and motorcycles is on the order of 0.5% of that which may result from automobiles.*

* In 1973 approximately 392 million gallons of gasoline were consumed in motorcycle usage as compared to 77.6 billion gallons for passenger cars in the same year. Based on Department of Transportation NEWS RELEASE dated December 31, 1974.

- Catalytic exhaust treatment for motorcycles, even if chosen by manufacturers as the preferred control approach, will not be initiated before 1980. Prior to this time, EPA will have fully evaluated the automotive sulfate situation and established a regulatory program as needed. Any regulatory program applied to automobiles could be applied to motorcycles as well before any motorcycles are introduced with catalytic control systems.
- Given that major changes in automotive exhaust emission control systems are required to reduce the sulfur emissions from automobiles, the technologies may be transferable to motorcycles.

2. Particulate Emissions

Uncontrolled particulate emissions from motorcycles (2-stroke in particular) are significant relative to those from automobiles. Table IV-8 presents a summary of emission factors for particulates from various automotive and motorcycle systems.

Particulate exhaust emissions from an uncontrolled two-stroke motorcycle exceed those of a conventional automobile. While most of the particulates from the automobile are lead compounds, two-stroke motorcycle particulates are primarily composed of carbon and high molecular weight organic compounds which are attributed to incomplete combustion of oil components. Four-stroke motorcycle particulate emissions are 85 percent lower than those for the two-stroke and are comparable to those for automobiles operated on unleaded fuel.

Table IV-8

PARTICULATE EMISSIONS FROM MOTORCYCLES AND AUTOMOBILES

	<u>grams/mile</u>	<u>(grams/kilometer)</u>
Motorcycle Exhaust		
Uncontrolled 2-Stroke	.33	(.21)
4-Stroke	.046	(.029)
Automotive Exhaust		
Non-Catalyst, Leaded Fuel	0.25	(0.15)
Non-Catalyst, Unleaded Fuel	.01-.02	(.006-.012)
Catalyst, Unleaded Fuel	.02-.08	(.01-.05)
Automotive Tire Wear	0.2	(0.12)

SOURCE: Motorcycle and Automotive Tire Wear, EPA Report AP-42. Automotive Exhaust, Appendix A-1, Annual Catalyst Report, EPA, 1975.

Future particulate emissions from both two-stroke and four-stroke motorcycles are likely to be reduced for two reasons. First, high emissions of organic particulates are probably attributable to the same factors producing high hydrocarbon emissions; i.e. operating rich, misfires, and fuel mixture short-circuiting. To meet the hydrocarbon emission levels proposed for 1978 and 1980, control measures will be utilized which will simultaneously and significantly reduce particulate emissions. Secondly, the lead phase down program^a for gasoline which EPA is implementing between now and 1980 will bring about a reduction in lead compound particulate emissions from both the automobile and motorcycle.

3. Hydrocarbon Reactivity

There is presently no indication of any direct health effects of the gaseous hydrocarbons in ambient air on populations, although as reactants in photochemical processes hydrocarbons can indirectly be linked with the adverse health effects of photochemical oxidants. This link with oxidant is the basis of hydrocarbon emission regulation.

"Hydrocarbon reactivity" is the term used to denote the relative ability of a specific hydrocarbon to participate in photochemical reaction processes. For instance, a specific hydrocarbon may be involved in several reactions in the photochemical process, depending on its concentration, structure and oxidation state. The end products of these reactions and the consequent intensity of the symptoms generated, such as eye irritation or plant damage, are largely dependent on the nature of the hydrocarbon involved.

^a EPA's regulations to phase down the lead content of leaded gasolines is presently in litigation.

A number of schemes have been proposed for rating the reactivity of hydrocarbons. These ratings are based on various phases of the photochemical process or its manifestations: (a) the rate of oxidation of nitric oxide to nitrogen dioxide; (b) the rate of disappearance of the hydrocarbon; (c) the yield of products or effects; and (d) most simply, whether a hydrocarbon does or does not react.

Based on the last criteria, one can generally define reactive hydrocarbons as all those other than methane, ethane, propane, benzene, and acetylene. This reactivity criteria is presently used in the development of oxidant implementation plans for California. Table IV-9 presents estimates of relative reactivity of hydrocarbon emissions from various mobile sources. One can see that uncontrolled hydrocarbon emissions are relatively more reactive than emissions from both catalyst and non-catalyst emission controlled automobiles.

As motorcycle emissions are controlled through engine modifications and/or exhaust treatment it is expected that not only the mass of total hydrocarbon emissions will be reduced but that the photochemical reactivity of these emissions will also be reduced. Reactivity of hydrocarbon emissions from controlled motorcycles should approach those shown in Table IV-9 for controlled automobile exhaust.

4. Water Pollution, Street Surface Runoff

Control of motorcycle exhaust emissions is expected to have a very small but beneficial impact on water washed into receiving waters by storm runoff.

Table IV-9

HYDROCARBON REACTIVITY FACTORS*

Light Duty Vehicles (Gasoline) Exhaust	
Non-catalyst (Controlled)	.77
Catalyst	.64
Heavy Duty Vehicles Exhaust	
Diesel	.99
Gasoline	.79
Motorcycles (Uncontrolled)	
2-Stroke	.96
4-Stroke	.86
Aircraft	
Turbine	.90
Piston	.90
Gasoline Vapors	.93

* Defined as the fraction of total hydrocarbons which are not methane, ethane, propane, benzene, or acetylene.

Motor vehicles, in general, contribute a broad range of street surface contaminants and in numerous ways. Although the contributions cannot be quantified, they can be listed by general category:

- leakage of fuel, lubricants, hydraulic fluids, and coolants
- fine particles worn off of tires and clutch and brake linings
- particulate exhaust emissions
- dirt, rust, and decomposing coatings which drop off of fender linings and undercarriages
- vehicle components broken by vibration or impact (glass, plastic, metals, etc.).

The generation rates of these materials have not been determined but probably correlate with season, geographic locale, and local traffic conditions.

Their importance as water pollutants varies substantially from material to material. Unburned fuel and lubricants degrade asphaltic pavements, thereby increasing the amount of inorganic solids loadings on receiving waters. Further, they float, causing films which are unsightly and hinder oxygenation. Like many other petrochemicals, they are damaging to biological forms. The lead, nickel, and zinc compounds used in their formulation are also harmful but to an undetermined extent.

The proposed regulations will reduce motorcycle emissions and will reduce emission of smoke and raw fuel and lubricating oil. This will have a slight beneficial impact on asphalt pavement degradation, and runoff organic loading.

5. Noise Control

A number of vehicle design parameters can be identified which are expected to affect both noise and emission levels to varying degrees:

- Gear ratios/Type of Drive System (direct or chain)
- Exhaust treatment devices
- Water cooling
- Air Intake System
- Weight of control devices
- Limited space for both noise and emission control devices

Some of these parameters are expected to cause a trade-off between noise and emissions. Information in this area is limited. Until control systems for both noise and air pollution emissions are better defined, the relationship between noise and emissions is not quantifiable. Nevertheless, it is apparent that noise and emissions are not independent; and both goals will have to be considered in vehicle and engine design.

Also of importance is the possible manpower strain of simultaneous noise and emission standards. Federal motorcycle noise standards appear to be a number of years away; motorcycle emission standards are likely to be implemented before EPA motorcycle noise standards. However, California has implemented motorcycle noise control standards. This means that the manufacturers already are faced with having to simultaneously meet noise and emission reduction requirements.

6. Energy Consumption

The 1978 and 1979 standards are expected to improve motorcycle fuel economy by about 15% (20% for 2-stroke and 10% for 4-stroke). Leaner mixtures, better fuel/air metering, mixing and atomization, and reduced two-stroke short-circuiting of intake air-fuel through the exhaust port, will all serve to reduce fuel consumption. This 15 percent improvement in fuel economy (miles per gallon) will mean a 13 percent reduction in fuel consumption (gallons per mile). The maximum energy impact is projected to occur at the end of 1979 when approximately 1.5 million motorcycles meeting these standards will be in-use. Assuming a base fuel consumption of .02 gallons per mile (50 mpg) and a usage rate of 3000 miles per year in the early years of ownership, a maximum fuel savings of 32,000 gallons per day is estimated. This is approximately 0.01 percent of the present U.S. fuel consumption for motor vehicles.

The fuel economy impact of the 1980 standards cannot be defined at this time due to the uncertainty about control system choice. If automotive technologies (stratified charge, lean burn, oxidation catalyst, etc.) prove to be transferable, controlled motorcycle fuel economy should be at least as good as that for uncontrolled motorcycles.

Chapter V

ECONOMIC IMPACT*

A. Characterization of the Industry

Four Japanese companies dominate the industry. Honda accounts for roughly 43 percent of total sales, with Suzuki, Kawasaki, and Yamaha having a relatively equal percentage of the industry. The only major domestic manufacturer is Harley-Davidson, accounting for around six percent of the total number of motorcycles sold each year. Table V-1 shows 1974 U.S. market shares by manufacturer.

Total employment in the U.S. motorcycle industry is about 95,000 people. Of this total, only about 3,500 are actually engaged in manufacturing motorcycles. Over 60,000 people work for the approximately 8,000 dealerships in the United States. The secondary products manufacturers and distributors account for about 27,000 employees. This segment of the industry supplies various accessories, and motorcycle-related products. Approximately 2,000 people work for publishers, insurance and financing companies and other assorted businesses which deal with motorcycles.

B. Cost of Achieving Standards

Estimates of the cost of achieving both the interim 1978 standards and the long term 1980 standards are highly uncertain. Since no standards exist the manufacturers

* This chapter has been extracted from a more detailed report prepared by Energy and Environmental Analysis, Inc. for EPA entitled, "Economic Assessment of Motorcycle Exhaust Emission Regulations", May, 1975.

Table V-1

MARKET SHARES IN MOTORCYCLE INDUSTRY (1974)^{1/}

Honda	42.91
Yamaha	20.28
Kawasaki	12.28
Suzuki	10.73
Harley Davidson	5.73
BMW	.89
Hodaka	.78
Norton	.70
Triumph	.68
Dultaco	<u>.42</u>
Total of Top Ten	95.90

^{1/} based on new motorcycle registrations

^{2/} Polk data shows Norton and Triumph separately. They are now merged and called Norton-Triumph.

Source: Motorcycle Industry Council based on data from R.L. Polk and Co.

have only performed a limited amount of research and development. The proposed interim standards were deliberately set at levels that were considered achievable with a minimum of disruption. The 1980 standards are expected to be more difficult to achieve, but attainable. Cost estimates for the 1978 standards range from \$20 to \$40 per motorcycle. For the purpose of this analysis, we have assumed that the cost would average \$30. Estimates for 1980 are subject to considerably more uncertainty.

The 1980 standard may require substantial modifications of engine designs and/or the addition of hardware such as catalytic converters. Honda, as a result of their automobile emission control program is considered to have an advantage over other manufacturers. Given the degree of uncertainty regarding the cost of achieving the 1980 proposed emission standards, three cost estimates were used. Table V-2 shows the range of cost estimates employed. Case 1 is intended to represent the cost if all manufacturers are able to meet the standards through engine modification. Case 2 represents the cost if catalytic converters are required. Case 3 represents the cost if Honda is able to perfect its stratified charged engine design, while all other manufacturers are forced to use catalytic converters.

C. Economic Impact on the Industry

The economic impact on the industry will depend on the response of consumers to higher prices. In order to estimate the impact, growth projections were made based on the current market outlook for new motorcycle sales through 1980. These projections were then modified to reflect the demand for motorcycles at the higher prices associated with

Table V-2

**COST ASSUMPTION FOR ACHIEVING THE 1980
MOTORCYCLE EMISSION STANDARDS**

	\$/Motorcycle	
Case 1	\$ 50	
Case 2	\$130	
Case 3		Honda
		\$ 50
		Others
		\$130

achieving the emission standards. Consumer reaction to higher price was estimated using two price elasticity of demand assumptions. The mid-range of the estimated economic impact is shown in Column 1 of Table V-3. Column 1 corresponds to the price assumptions in Case 3 (Table V-2) and a price elasticity of demand of around 0.7. Unit sales under these assumptions would be expected to decrease from the baseline projection by approximately 7.1 percent, and revenues to increase by 2.0 percent. The apparent anomaly of sales decreasing but revenues increasing results from the assumption of less than a unity price elasticity. If increasing the average price by 1.0 percent causes sales to decrease by less than 1.0 percent, revenues will increase. Under these assumptions, the average price would be expected to increase by around 10 percent. The increase in the average price of motorcycles reflects not only the increased cost of each motorcycle for the emission control system, but also the expected shift in sales away from the smaller (less expensive) motorcycles. As mentioned earlier, the assumption that the emission control system for a small displacement motorcycle will cost as much as that for a large displacement motorcycle results in a projected shift in sales away from the smaller motorcycles because of greater percentage increase in the price of the small motorcycles. Approximately one-third of the average increase in the price of motorcycles is associated with the shift in sales. Column 2 represents the range over which the actual impact might fall.

The effects of the proposed regulations may vary greatly between firms in the industry. Cost estimates used to determine impacts are average costs, and individual firms may face costs higher or lower than this average. Sizes of firms, mix of engine sizes and types, production methods, engineering abilities, and pricing strategies vary

TABLE V-3
AVERAGE EXPECTED IMPACT OF
PROPOSED 1980 EMISSION STANDARDS

	(1)	(2)
	Average	Range
Unit Sales (10^3 units)	1,343.3	1,233.4 to 1,421.0
% Change from Baseline	-7.1	-14.7 to -1.7
Revenues (10^6 \$)	\$1,636.8	\$1,572.3 to \$1,723.1
% Change from Baseline	+2.0	- 1.7 to + 7.7
Average Cost (\$/unit)	\$1,219.0	\$1,161 to \$1,275
% Change from Baseline	+10.1	+ 4.9 to +15.2

greatly in the industry. Very small firms may well find that their costs of meeting the standards (especially in 1980) will be considerably higher than the large manufacturers. Their production costs, research and development capabilities and especially the number of units over which fixed costs are spread may be significantly different from large manufacturers. The fixed costs of certification, for example, can be spread over a larger number of motorcycles for Honda than it can for Ducati. Ducati produced only 971 motorcycles which were registered in 1974. EPA estimates that for the 4 large Japanese manufacturers certification costs would average 0.145 percent of the retail price of a motorcycle, while full certification costs for a small manufacturer of less than 2,000 units would be as high as 3 to 6 percent of retail price. Planned reductions in certification requirements for small manufacturers will reduce the cost disadvantage in this one area, but other effects on very small producers may involve larger than average cost increases for these manufacturers.

D. Cost Effectiveness

The cost effectiveness of controlling motorcycles can be compared to other techniques which reduce HC and CO emissions from light duty vehicles and gasoline stations. In terms of kilograms controlled per dollar spent, the cost effectiveness of controlling motorcycles relative to the cost effectiveness of controls on LDV's varies depending on the motorcycle engine size and type. Table V-4 and Table V-5 summarize a cost effectiveness comparison between motorcycle emission control standards and other light duty vehicle control options.

Table V-4

COST EFFECTIVENESS OF MOTORCYCLE
EMISSION CONTROL STANDARDS

<u>STANDARD</u>	<u>MOTORCYCLE TYPE</u>	<u>DISPLACEMENT</u>	Kilograms Controlled per \$ Spent	
			<u>HC</u>	<u>CO</u>
1978 ^{1/}				^{2/}
	2-Stroke	<170cc	1.4	—
	2-Stroke	> 170cc	19.3	24.0
	4-Stroke	< 170cc	—	—
	4-Stroke	> 170cc	—	24.0
1980 ^{3/}				
	2-Stroke	< 170cc	0.6-2.9	0.9-4.3
	2-Stroke	> 170cc	2.3-11.8	4.5-22.4
	4-Stroke	< 170cc	0.1-0.5	0.9-4.3
	4-Stroke	> 170cc	0.5-2.4	4.5-22.4

1. Assumes a first cost of \$30 and 15% improved fuel economy.
2. Blanks indicate no control required by 1978 standards.
3. Effectiveness based on incremental costs and reductions over the 1978 standards. Range reflects first cost estimates of \$50 and \$130.

Source: Energy and Environmental Analysis, Inc., "Economic Assessment of Motorcycle Exhaust Emission Regulations", prepared for EPA, May, 1975.

Table V-5

COST EFFECTIVENESS OF LIGHT DUTY VEHICLE
SECONDARY CONTROL OPTIONS (IF IMPLEMENTED IN 1977)

<u>MEASURE</u>	<u>ESTIMATED EFFECTIVENESS</u> (Kilograms controlled per dollar invested)	
	<u>HYDROCARBONS</u>	<u>CARBON MONOXIDE</u>
Auto Inspection and Maintenance	≈0.7	≈7.5
Catalytic Retrofit	≈0.7-0.8	≈8-11
VSAD ^{1/} Retrofit	≈3.0	≈13-14
Air Bleed Retrofit	≈2-2.5	≈80-85
Gasoline Station Control	≈4-5	N.A.

1/ VSAD=Vacuum Spark Advance Disconnect

Source: The Clean Air Act and Transportation Controls - An EPA White Paper (adjusted to 1974 dollars and converted to kilograms.)

It should be noted that the motorcycle modifications being considered will yield reductions in both pollutants. However, it is not possible to determine the cost of controlling only one of the pollutants. Therefore, in calculating cost-effectiveness, the fuel price of the emission control system has been used as the cost of controlling hydrocarbons and also as the cost of controlling carbon monoxide. It should also be noted that, in this analysis, it has been assumed that the cost of meeting the standards does not vary with engine type or engine displacement and that this cost is passed forward to the consumer equally for each class of motorcycle. This assumption is most likely incorrect but is used here since data is not available with which to quantify any likely cost differences. In general, one could expect that it will cost somewhat less to control four-stroke engines than two-stroke engines and that it will cost somewhat less to control the smaller displacement engines than the large displacement engines. Thus, the cost effectiveness of controlling the less than 170 cc two-stroke motorcycles and greater than 170 cc four-stroke motorcycles is likely to be higher than shown in Table V-4, and the cost-effectiveness of controlling less than 170 cc four-stroke engines is likely to be considerably higher than shown in Table V-4. Nevertheless, lacking the data with which to quantify these likely differences, the following conclusions are based on the numbers shown in Table V-4.

For the 1978 standards, control of HC emissions from 2-stroke motorcycles larger than 170 cc is more cost effective than any of the LDV techniques considered. Control of HC alone (although in fact modifications will control both HC and CO) from 2-strokes smaller than 170 cc is more cost effective than LDV catalysts, but less cost effective than air bleed retrofit on LDV's. Control of CO for motorcycles larger than 170 cc is more cost effective than all LDV techniques considered except air bleed.

For 1980 standards, the cost effectiveness of motorcycle regulation relative to LDV control options depends on the cost of the motorcycle modifications. Exact cost estimates are uncertain but at either a \$50 or \$130 cost, control of 4-stroke motorcycles less than 170 cc would not be cost effective compared to the LDV control techniques considered. For large 2-strokes, a cost of \$50 for 1980 modifications would make their control cost effective for HC reduction relative to all the LDV programs considered. A \$100 cost would make them less cost effective than gasoline station controls or vacuum spark advance disconnect on LDV's. Control of other sizes and types of motorcycles have varying cost effectiveness relative to LDV techniques. The cost effectiveness depends on the pollutant being controlled and the cost assumed for modifications.

Chapter VI

OTHER GENERAL CONSIDERATIONS

A. Irreversible and Irretrievable Commitment of Resources

The major commitment of natural resources associated with the proposed new motorcycle emission standards relates to the approach taken by the manufacturer to achieve the standards. Although this cannot be accurately determined at this time, analogies to automotive control will provide some evidence of potential commitment of resources. In general, any resource commitment is expected to be negligible.

If any manufacturers use catalyst converters to meet the proposed 1980 standards, an additional commitment of platinum, palladium and steel would be required over and above that needed for automobiles. The demand for platinum and palladium by 1990 might be as high as 10 percent of the automotive demand, or less than 100,000 troy ounces per year. An increase of this size would not strain world production capabilities.

Commitments of other resources such as steel, aluminum, etc. are so small as to be over-shadowed by normal market fluctuations.

There is the potential that the 1980 standard for NO_x could result in an increase in gasoline consumption in comparison to the 1978 and 1979 model years. However, fuel economy relative to an uncontrolled motorcycle is not expected to decrease. As such, no increase in gasoline consumption is forecast.

B. Relationship of Short-Term Uses of the Environment and Maintenance and Enhancement of Long-Term Productivity

Regulation of motorcycle emissions results in a substantial decrease in carbon monoxide and hydrocarbon emissions from this

source. The hydrocarbon reduction will be most substantial for the reactive hydrocarbons (those which result in smog formation). This reduction will be beneficial and aid in the long-term attainment and maintenance of acceptable air quality levels.

Emissions of NO_x from motorcycles are expected to increase under the proposed regulations. However, motorcycles are expected to be a very small source nationally of NO_x , less than 0.1 percent.

Chapter VII

ALTERNATIVES TO THE PROPOSED ACTION

Alternative actions include:

- Take no action to reduce the emissions of hydrocarbons and carbon monoxide.
- Implement alternative emission standards for motorcycles.
- Regulate hydrocarbon and carbon monoxide emission sources other than motorcycles to a greater degree.

Each will be addressed in this section.

A. Take No Action to Reduce HC and CO Emissions

As demonstrated earlier in this statement, motorcycle emissions, left uncontrolled, are expected to increase by over 100 percent between now and 1990. Between now and 1990 emissions of other sources will be significantly curtailed as attainment of acceptable air quality is pursued, and the importance of motorcycle emissions in finally achieving the air quality standards will be increasingly important. It has also been shown that a large number of the regions presently exceeding the air quality standards for oxidants and carbon monoxide will continue to have difficulties in achieving or maintaining these standards in the 1980's. Uncontrolled emissions from motorcycles will add to this burden.

Perhaps the strongest argument for the control of motorcycles emissions is one of equity. Present uncontrolled motorcycles emit about two times as much CO and about six times as much HC as new automobiles. When statutory standards for automobiles are met, uncontrolled CO emissions will be ten times as high and HC over twenty times as high for the motorcycle. Distribution of the burden of control for emissions from personal transportation would be unjustly disproportionate if motorcycles were to remain uncontrolled.

Table VII-1

**SCENARIOS FOR ALTERNATIVE
MOTORCYCLE EMISSION REGULATIONS**

- BASE CASE** - No Regulations promulgated, motorcycle emissions remain uncontrolled.
- PROPOSED STDS.** - HC phase-in standards of 5 grams per kilometer for ≤ 170 cc, 14 grams per kilometer ≥ 750 cc with linear scale between 170 and 750cc with CO at 17 grams per kilometer and NO_x at 1.2 grams per kilometer. Set 1980 standards at statutory HC, CO and NO_x levels for LDV.
- ALTERNATIVE I** - Set same phase-in standards and 1980 standards as proposed except replace HC phase-in standard with single level HC standard of 5 grams per kilometer.
- ALTERNATIVE II** - Set same phase-in standards and 1980 standards as proposed except replace proposed HC phase-in standard with single level standard of 8 grams per kilometer.
- ALTERNATIVE III** - Set same phase-in standards as proposed but set less stringent 1980 standards of .93 gms/km HC, 9.3 gms/km CO, and 1.2 gms/km NO_x (same standards as required for 1977 light duty passenger vehicles as a result of the Administrator's Suspension Decision of March 5, 1975).

B. Alternative Standards for Motorcycle Emissions Regulation

Projections of total motorcycle fleet emissions of exhaust HC, CO and NO_x have been developed for the no control case, the proposed action and three alternative control standards packages. The various alternatives are described in Table VII-1 and the new vehicle emission factors reflecting these scenarios are given in Table VII-2.

Alternative I includes a tighter phase-in standard than the proposed action, and Alternative II a less stringent phase-in limitation. Alternative III reflects less stringent long-term emission standards, equivalent to those for automobiles in 1977.

Alternative I, which would set the 1978 HC phase-in standard at 5 g/km, and Alternative II, which would set the phase-in HC standard at 8 g/km are both likely to prevent certification of certain large two-stroke motorcycles. The technical opinion of EPA is that if the 5 g/km standard were implemented, it would mean that all two-stroke engines over 350 cc would not meet the standards, and if the 8 g/km HC standard were implemented, two-stroke motorcycles at or above 550 cc would not meet the standards. The short term economic impact of these alternative phase-in standards could be significant.

Thirty-one percent of Suzuki's unit sales are of two-stroke motorcycles with displacement greater than 350 cc. On a dollar volume basis, the higher cost of these motorcycles makes them even more important as a percentage of total sales. Kawasaki, Yamaha and a number of other smaller producers of large two-stroke motorcycles would also suffer losses, although on a percentage basis they could, in most cases, be less than Suzuki's losses.

With these alternative phase-in standards, total reductions in industry sales would not be as significant as disruption of

TABLE VII-2
EXHAUST EMISSION FACTORS USED IN
EMISSION PROJECTIONS

(grams per kilometer)				
Case	Motorcycle Size (cc)	Hydrocarbons	Carbon Monoxide	Nitrogen Oxides
Base -	<170	4.4	9.3	0.09
No Control	>170	5.7	22.5	0.07
Proposed				
Standards				
1978	<170	2.9	9.3	0.09
	>170	4.0	16.5	0.62
1980	ALL	0.25	2.1	0.25
Alternative I				
1978	<170	2.9	9.3	0.09
	>170	2.9	16.5	0.62
1980	ALL	0.25	2.1	0.25
Alternative II				
1978	<170	4.4	9.3	0.09
	>170	4.0	16.5	0.62
1980	ALL	0.25	2.1	0.25
Alternative III				
1978	<170	2.9	9.3	0.09
	>170	4.0	16.5	0.62
1980	ALL	0.9	9.3	1.05

the competitive structure of the industry. Four-stroke motorcycles are, to a large extent, substitutes for two-stroke motorcycles in the eyes of many consumers. Any disappearance of large two-stroke motorcycles would most likely mean that four-stroke manufacturers (subject to production capability constraints) would attempt to increase production and fill the gap in sales. The competitive advantage for four-stroke manufacturers is great in the case of any regulation which causes the loss of a large portion of the two-stroke manufacturers' lines. The large two-stroke production category is not significant for Honda, but is of great importance to both Suzuki and Kawasaki.

The differential economic impact of Alternative III (which has less stringent long-term standards) versus the proposed action cannot be assessed at this time. As has been indicated previously in this assessment, little is known about the kind of control hardware which will be used to achieve the proposed long-term standards and, although it is true that the long-term standards set forth in Alternative III would be more easily met than the proposed standards, it is not clear at this time that any cost or performance benefits would be derived from setting the less stringent long-term standards.

Figures 7-1, 7-2, and 7-3 show the projected fleet emissions of HC, CO and NO_x under each of the scenarios. Alternatives I and II provide essentially the same emissions impact for all three pollutants as the proposed action. Alternative III has significantly less impact on long-term HC and CO emissions and allows a much greater increase in NO_x emissions than the action presently being proposed.

C. Further Regulation of Alternative Emission Sources

On March 5, 1975, EPA Administrator Russell Train announced the interim automotive emission standards for the 1977 model year and

Figure 7-1

PROJECTED FLEET EMISSIONS OF EXHAUST
HYDROCARBONS UNDER ALTERNATIVE CONTROL SCENARIOS

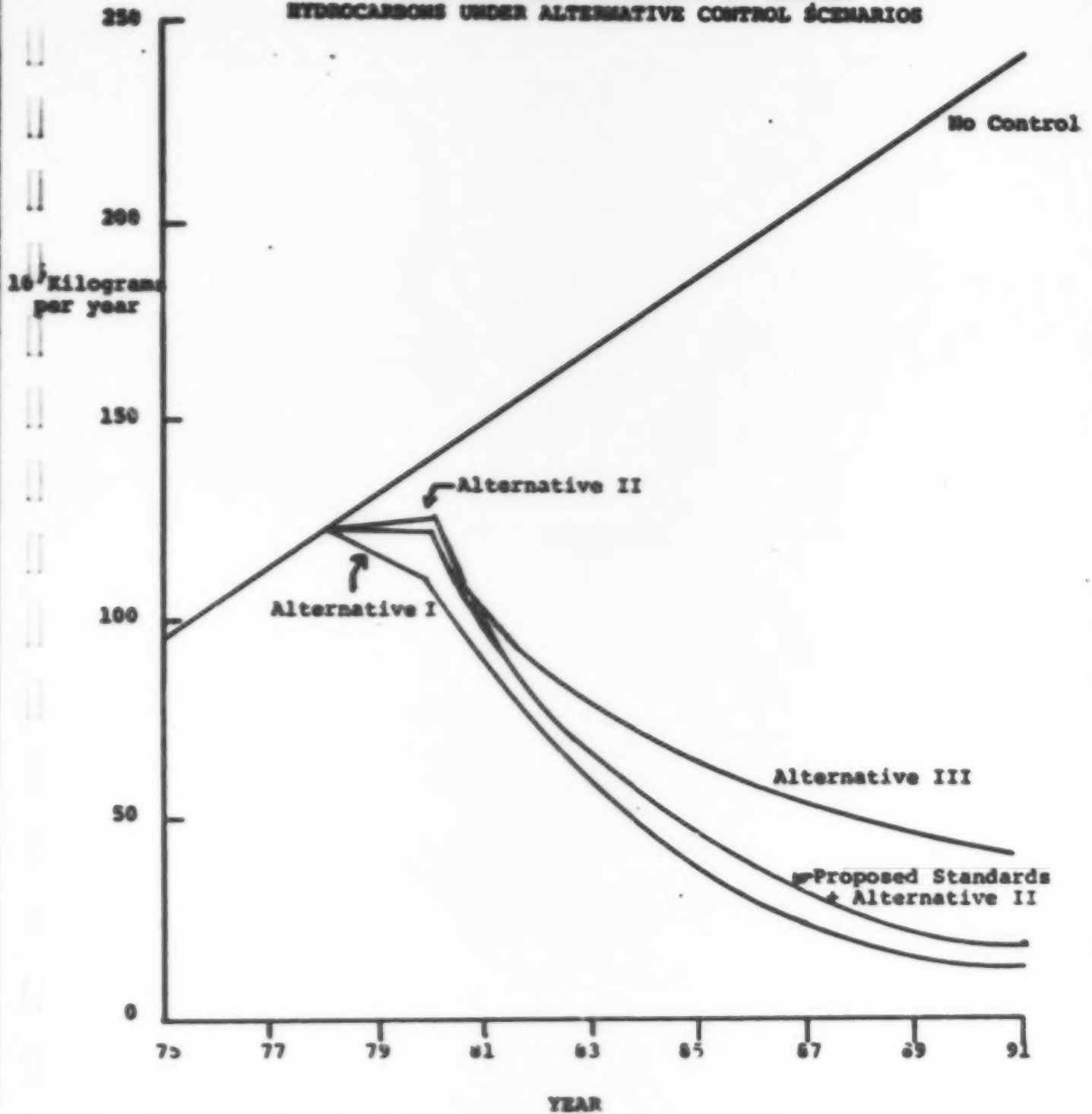


Figure 7-2

PROJECTED FLEET EMISSIONS OF CARBON MONOXIDE
UNDER ALTERNATIVE CONTROL SCENARIOS

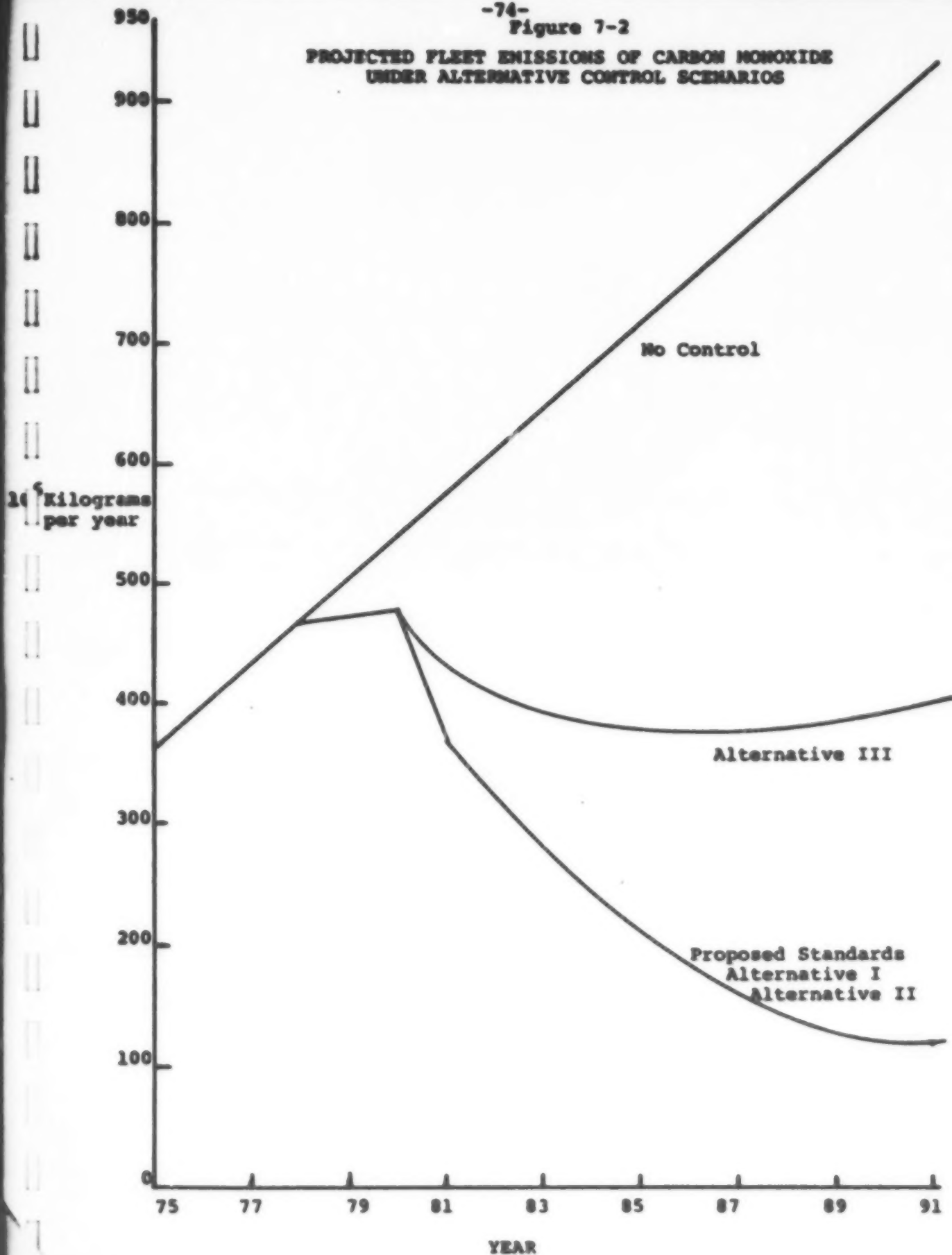
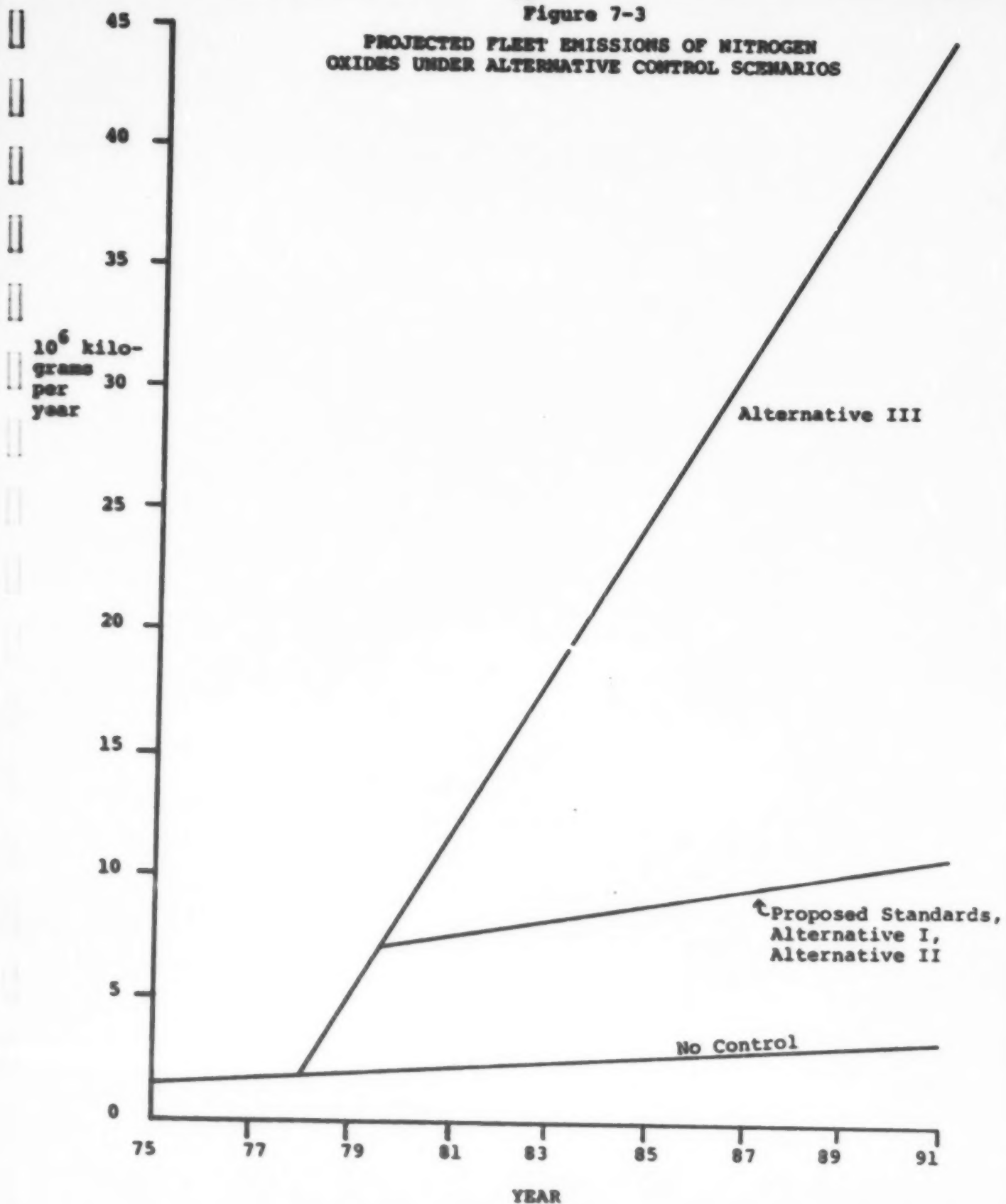


Figure 7-3

PROJECTED FLEET EMISSIONS OF NITROGEN
OXIDES UNDER ALTERNATIVE CONTROL SCENARIOS



recommended the delay of statutory HC and CO automotive emission standards to 1980 in light of the automotive sulfates emission problem. In light of continuing difficulties in achieving the oxidant and carbon monoxide air quality standards in major urban areas and the fact that the more stringent automotive emission standards may be delayed, EPA is taking a new look at the potential for further reduction of alternative emission sources of hydrocarbons and carbon monoxide.

During the same March 5th press conference, Administrator Train announced several actions designed to provide additional reductions in emissions of hydrocarbons and carbon monoxide from other sources. The actions include:

- "1. More stringent emissions will be proposed for heavy duty vehicles.
2. A new evaporative emission standard for automobiles will be proposed for the 1978 model year.
3. Motorcycle emission standards will be set for the 1978 model year.
4. Existing standards requiring a 90 percent reduction in hydrocarbon emissions during vehicle refueling must result in use of the most effective control devices which are available or can be developed.
5. EPA will re-examine current regulations providing for hydrocarbon control from paints, solvents, dry-cleaning liquids, and refineries with a view to tightening them."

Further control of other emission sources is not an alternative to motorcycle emission standards but complements these standards as a part of EPA's overall program to improve air quality.

APPENDIX A

**100 Largest Standard Metropolitan Statistical Areas
Ranked by Ratio of Registered Motorcycles per 100 Population**

Rank	City -- S.M.S.A.	Population 1970 Census	Autos and Trucks	Motorcycles	Number Motorcycles per 100 People
1	Bakersfield, CA	329,162	211,420	14,224	4.32
2	Riverside, San Bernardino, Ontario, CA	1,143,146	683,646	40,677	3.56
3	Anaheim, Santa Ana, Garden Grove, CA	1,420,386	889,935	50,154	3.53
4	Salt Lake City, UT	557,635	361,525	19,676	3.52
5	Sacramento, CA	800,592	498,466	28,097	3.51
6	Oxnard, Simi Valley, Ventura, CA	376,430	223,406	13,047	3.46
7	Wichita, KA	389,352	254,673	13,142	3.37
8	San Diego, CA	1,357,854	709,723	44,604	3.28
9	Albuquerque, NM	315,774	206,796	10,187	3.23
10	Tulsa, OK	476,945	320,682	14,070	2.95
11	Oklahoma City, OK	640,889	443,922	18,843	2.94
12	San Jose, CA	1,064,714	654,443	31,124	2.92
13	Fresno, CA	413,053	261,023	12,013	2.91
14	Jacksonville, FL	528,665	319,216	11,018	2.91
15	Lansing, East Lansing, MI	378,423	196,098	11,920	2.91
16	Portland, OR-WA	1,009,129	535,975	28,742	2.84
17	Los Angeles, Long Beach, CA	7,032,075	4,133,579	195,034	2.77
18	Grand Rapids, MI	539,225	292,235	14,218	2.64
19	Flint, MI	496,260	260,645	12,903	2.59
20	Phoenix, AZ	967,522	659,879	24,141	2.49
21	San Francisco, Oakland, CA	3,109,519	1,757,966	77,462	2.49
22	Tucson, AZ	351,667	230,995	8,607	2.45
23	Denver, CO	1,227,529	835,855	29,771	2.43
24	Fort Worth, TX	762,086	499,181	18,347	2.41
25	West Palm Beach, FL	348,753	245,654	8,256	2.36
26	Seattle, Everett, WA	1,421,669	816,799	28,983	2.04
27	Omaha, NB-IO	540,142	303,649	11,894	2.20
28	Fort Lauderdale, Hollywood, FL	620,100	463,447	13,462	2.17
29	Minneapolis, St. Paul, MN	1,813,647	986,555	36,005	1.99
30	Davenport, Rock Island, Moline, IA-IL	362,638	208,164	7,099	1.95
31	Dallas, TX	1,555,950	962,255	30,079	1.93
32	Orlando, FL	426,603	300,305	7,961	1.86
33	Tacoma, WA	411,027	235,505	7,700	1.85
34	Peoria, IL	341,979	192,121	5,915	1.72
35	Detroit, MI	4,199,931	2,141,715	70,327	1.67
36	Indianapolis, IN	1,109,882	603,687	18,740	1.67
37	Houston, TX	1,985,031	1,193,130	33,051	1.67
38	Dayton, OH	850,266	492,914	13,810	1.62
39	Knoxville, TN	400,337	218,572	6,414	1.60
40	Toledo, OH-MI	692,571	388,116	11,086	1.60
41	Atlanta, GA	1,390,164	862,944	21,724	1.56
42	El Paso, TX	359,291	183,913	5,589	1.55
43	Akron, OH	679,239	392,179	10,404	1.53
44	Tampa, St. Petersburg, FL	1,012,594	673,925	15,386	1.52
45	Chattanooga, TN-GA	304,927	168,475	4,858	1.50
46	Birmingham, AL	739,274	434,262	10,917	1.47
47	San Antonio, TX	944,943	582,682	4,444	1.43
48	Miami, FL	1,267,392	815,237	17,994	1.42
49	Columbus, OH	916,278	504,513	12,955	1.41
50	Mobile, AL	976,690	211,578	5,196	1.37
51	Little Rock, North Little Rock, AR	923,256	190,311	4,356	1.34
52	San Jose, CA	1,064,714	654,443	31,124	2.92

Rank	City-S. M. S. A.	Population 1970 Census	Autos and Trucks	Motorcycles	Number Motorcycles per 100 People
53	Honolulu, HA	829,178	326,998	8,323	1.32
54	San Antonio, TX	884,014	450,610	11,119	1.29
55	Cincinnati, OH-KY-IN	1,384,851	721,989	17,692	1.28
56	Youngstown, Warren, OH	536,003	309,152	6,848	1.28
57	Gary, Hammond, E. Chicago, IN	633,367	304,925	7,916	1.25
58	Harrisburg, PA	410,626	180,783	5,105	1.24
59	Lancaster, PA	319,600	140,782	3,976	1.24
60	Pittsburgh, PA	2,401,245	1,050,202	29,885	1.24
61	Wilkes-Barre, Hazleton, PA	342,301	150,052	4,255	1.24
62	York, PA	329,510	144,938	4,093	1.24
63	Canton, OH	372,210	210,206	4,556	1.22
64	Memphis, TN	770,120	353,245	9,241	1.19
65	Allentown, Bethlehem, Easton, PA-NJ	543,551	244,138	5,841	1.08
66	Milwaukee, WI	1,403,688	641,515	14,474	1.03
67	Chicago, IL	6,978,947	3,050,805	66,805	.99
68	Cleveland, OH	2,064,194	1,026,698	19,626	.95
69	Pecan, IL	341,979	192,126	5,915	.94
70	Louisville, KY-IN	826,553	454,475	7,609	.92
71	Columbia, SC	322,880	173,048	2,720	.84
72	Wilmington, DE-NJ-MD	499,493	223,697	4,135	.82
73	Utica, Rome, NY	340,670	151,602	2,471	.76
74	Rochester, NY	882,667	413,362	6,551	.74
75	Baltimore, MD	2,070,670	956,572	14,336	.69
76	Syracuse, NY	636,507	299,854	4,292	.67
77	Washington, DC-MD-VA	2,861,123	1,424,403	17,612	.61
78	Buffalo, NY	1,349,211	575,563	7,830	.60
79	Albany, Schenectady, Troy, NY	721,910	330,797	3,790	.52
80	New York, NY	11,571,899	3,627,091	30,443	.26

Source: Motorcycle Industry Council.

APPENDIX B

APPENDIX B

NATIONWIDE IMPACT OF MOTORCYCLE EMISSIONS

	<u>1970</u>	<u>1980</u>	<u>1990</u>
<u>Motorcycles*</u>			
Registrations (millions)	2.25	7.5	11.9
Annual VMT (billions)	4.5	16.3	26.2
Relative Total HC/CO Emissions (No control)	1.0	3.6	5.8
Relative Total Emissions (With proposed controls)			
- HC	1.0	2.2	0.4
- CO	1.0	2.3	0.7
- NO _x	1.0	12.2	19.5

National Emissions Trends**

Shift in Urban Emissions Due to
Overall *** Control Measures

- HC	1.0	0.81	0.70
- CO	1.0	0.46	0.30
- NO _x	1.0	1.18	1.22

Mobile Source (%) of Total

- HC	59%	58%	52%
- CO	98%	94%	89%
- NO _x	47%	41%	30%

* Based on Projections of Motorcycle Use and Control by Energy and Environmental Analysis, Inc., May, 1975.

** From EPA Report, "Air Quality Impact of Alternative Emission Standards for Light Duty Vehicles," March 1975.

*** Stationary and Mobile Sources.